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Human Performance Data Relevant to the Amored Family of Vehicles

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for

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For this report, human performance findings and issues relevant to the Armor Family of Vehicles (AFV) were abstracted from past literature in the areas of encapsulation, information processing, continuous operations, and maintenance. Emphasis was placed on selecting documents that contain quantitative data and information easily generalizable to the AFV soldier and tasks. Implications for the design, training, and manpower requirements for the AFV were developed from the documents. The report is organized to provide varying levels of detail required by personnel involved with AFV MANPRINT issues. The detailed findings and implications for each of the four areas were placed in a hardcopy database (Appendix C) and summarized in narrative form in the results section. Material useful for briefing purposes is located in Appendix B. Sections can be used separately or as part of the whole, depending on the user's need. Keywords

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Maintenance findings indicate that current maintenance effectiveness could be substantially improved. Improvements could be made through equipment design, training, supervision, job aiding, and automated test equipment.

Utilization of Findings:

The hard copy database contained in this report can be used to assist those requiring human performance information relevant to the AFV for the purposes of developing training, design, or manpower requirements. The database can be used at several levels of detail from viewgraph summary to actual findings reported in the studies. Some research voids and possible future research areas have also been identified and could be used to develop new research programs aimed at human performance issues relevant to the AFV.

HUMAN PERFORMANCE DATA RELEVANT TO THE ARMORED FAMILY OF VEHICLES

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HUMAN PERFORMANCE DATA RELEVANT TO THE ARMORED FAMILY OF VEHICLES

OVERVIEW

Operational Problem

With the concept exploration phase of the Army's Armored Family of Vehicles (AFV) and the implementation of the Army's Manpower and Personnel Integration (MANPRINT) program came the need for research on human performance issues relevant to the AFV. The identification and summarization of relevant past research serves as an aid in the determination of human performance issues, research voids, and possible solutions, as well as future research needs for the AFV. Relevant quantitative human performance data are potentially useful in evaluating MANPRINT risks and subsequently useful in determining the developmental and engineering design requirements supporting the human performance demands of the AFV system concept.

Research Objective

The purpose of this research was threefold. First, to provide a hardcopy data base of information in four major areas of risk relevant to the human performance issues in the MANPRINT program for the AFV. The four risk areas were 1) encapsulation; 2) information processing; 3) continuous operations; and 4) maintenance. The second purpose was to summarize the relevant data in the four risk areas in such a way as to provide answers or illuminate new human performance MANPRINT issues for the AFV. The third purpose was to identify research voids and future research needs for human performance issues in the AFV in order to assist in guiding the direction of future MANPRINT research directed at AFV.

Scope

The scope of this research project was defined in terms of the four main risk areas identified above by the AFV MANPRINT Steering Committee as being particularily important from the MANPRINT perspective. The information contained in this data base was obtained from an extensive review of the existing literature on the above four topics with an emphasis on quantitative results. Because of time constraints, the literature review was restricted to the most relevant and representative information relating to AFV human performance MANPRINT issues. It is anticipated that this data base and summary of existing research will assist those personnel involved during the various phases of the acquisition process by providing some of the MANPRINT human performance data related to the AFV which can be used to develop design, training and manpower requirements.

Constraints

This research product was originally intended to support a Headquarters Department of the Army In Process Review (IPR) on August 18, 1987. The purpose of this IPR was to assess the overall technical risk of the AFV project and to determine if the program should continue. However, the research project was not initiated until late June. Therefore, this project represents about 70 professional staff days of work. Along with this time constraint a Special Task Force (STF) appointed by the Deputy Chief of Staff for Operations and Plans (DCSOPS) changed one of the risk areas from "realistic doctrine and battlefield security" to "effects of continuous operation". Because of these constraints the present review of the literature cannot be considered exhaustive. It was the intent of the research team to locate and summarize the most relevant and representative research available within the time constraints. There will be a continual need to update the data base as new research is produced.

How to Use the Report

The report is divided into a number of different sections, some of which may be used alone or in conjunction with other sections depending on the level of detail required and the user's needs. The results section provides a narrative of the more relevant research findings for each of the four risk areas. Within each risk area, implications for design, training and manpower requirements are presented. It is not necessary, although recommended, to read the research findings in order to use the implications. The findings are also presented in Appendix B as input material for briefings on human performance MANPRINT findings relevant to the AFV. For those requiring more information regarding the data presented, the briefing input material references data sheets located in Appendix C. These data sheets provide detailed abstracted data and information along with implications relevant to human performance MANPRINT issues for the AFV. Appendix A contains an alphabetized reference list of all the documents which were abstracted and may be used in conjunction with references cited in the results section to locate information in Appendix C. Finally, the discussion section of this document presents general research voids and suggests possible future research directions.

BACKGROUND

The Army's AFV concept development program, begun in 1986, is aimed at developing an armored vehicle family that will include a full range of vehicles with maximum component commonality.

Commonality is not a new idea; both U.S. and foreign automobile manufacturers have been relying extensively on standardized parts for many years to help keep developmental and production costs down. In Army combat vehicles, there are common subsystems such as engines, transmissions and electronics, and common chassis in such vehicle families as the M2/M3 Bradley. However, the AFV as now envisioned would represent the most ambitious use of this idea for the Army.

The new armored family may include two or three common chassis that could be combined with any of various subsystem modules--each designed for a specific mission--to build a full range of armored vehicles. To build a tank, for example, there would be a module outfitted with a main gun and a fire-control system. A recovery vehicle would have a module with a crane and winches. For an infantry vehicle, there would be an armored module designed to carry troops.

Given this commonality, important logistics and training benefits should be evident; certainly, it would be much easier to train mechanics and drivers. Also, it would be cheaper to buy large quantities of parts common to the entire fleet than to buy smaller quantities of unique parts for each vehicle type. Thus, there is a great potential for reduced overall vehicle sustainment costs.

If the projected acquisition schedule is adhered to, full-scale AFV development will get under way in 1990, with introduction of vehicles to troops possible during the mid 1990s.

An essential part of the early concept exploration stage is the work currently conducted by the Armored Family of Vehicles Special Task Force (AFV-STF). The AFV-STF provides the central focus on the project and coordinates all the various research projects currently exploring the myriad requirements for fielding a new family of vehicles. These projects extend from new engine and material technologies to training and crew performance. An integral part of AFV-STF is the MANPRINT Steering Committee which provides specific guidance on manpower, personnel, training, human factors, system safety and health hazards as they relate to the various research and development tasks.

Risk Areas

The AFV MANPRINT Steering Committee identified four major risk areas from the MANPRINT perspective. These four areas were 1) encapsulation; 2) information processing; 3) continuous operations (CONOPS); and 4) maintenance. A number of human performance MANPRINT issues related to these risk areas were identified by the Steering Committee as relevant to the AFV concept. This list was expanded by the present research staff in order to assist in defining the relevant areas of literature to review. These expanded issues and subissues are presented in Table 1.

The present effort focused on determining AFV human performance issues which had already been examined in past research. This process was guided by, but not limited to, the list of issues presented in Table 1. It is anticipated that past research will not be able to offer answers to all or even a majority of the issues and subissues. Those issues which cannot be answered directly by past research could be considered research voids and could be used to guide future research programs. The list is expected to expand and be revised as past research, current and future research will address older issues and bring to light new issues that are useful in developing design requirements for the AFV.

Table 1. AFV Issues-Subissues List

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1. ENCAPSULATION — What is the effect of crew confinement in an enclosed armored vehicle on crew performance in combat?

   A. SUSTAINED OPERATIONS OF ENCAPSULATED CREWS - To what extent can encapsulated crews perform required tasks effectively over sustained periods of combat? To what extent does prolonged encapsulation affect crew performance after they are released from encapsulation (effects of disorientation)?

   B. OPERATIONAL REQUIREMENTS OF SOLDIERS, CREWS, AND UNITS - To what extent are operational requirements of encapsulated soldiers, crews, and units achievable through the use of encapsulation support equipment (e.g., oxygen filtration and temperature/humidity support systems, visual monitoring systems)?

   C. FEASIBILITY OF INDIRECT VISUAL MONITORING - To what extent are indirect visual monitoring systems feasible for use in AFV crew tasks which require external visual information (e.g., surveillance tasks to identify enemy threat)?

   D. INTERACTION OF CREW ENCAPSULATION WITH PERFORMANCE SHAPING FACTORS - To what extent would crew encapsulation interact with soldier performance shaping factors (e.g., lack of confidence in indirect visual monitoring systems, communications, decontamination procedures, recoil vibrations (especially multiple fires), mobility, environmental systems, crew space layout, dietary sufficiency, clothing, personal hygiene, sleep deprivation, crew rotation, fatigue, heat stress, motion sickness, and workload)?

2. INFORMATION PROCESSING - What are the effects of workload and fatigue on crew performance of critical high cognitive skill tasks?

   A. AFV DESIGN TO REDUCE COGNITIVE OVERLOAD - What are the AFV soldier-machine interface design requirements for reducing cognitive overload conditions, enhancing soldier performance of critical tasks during sustained operations (in spite of fatigue effects), and maintaining coherent workload among crewmembers?

   B. INFORMATION REQUIREMENTS FOR ENCAPSULATED CREWS - What are the information needs of encapsulated AFV crews to facilitate the performance of critical operations tasks?

2. INFORMATION PROCESSING (Cont'd)

   C. COMMAND AND CONTROL INFORMATION REQUIREMENTS - What are the information requirements in order to assure necessary command and control of AFV units?

   D. MINIMUM INFORMATION REQUIREMENTS AND MAXIMUM TOLERABLE WORKLOAD DURING DEGRADED MODE OPERATIONS - What are the minimum information needs of encapsulated crews and maximum tolerable workload to perform critical operations tasks during degraded mode (meaning manual armored vehicle) operations? What are the minimum information needs and maximum tolerable workload of a reduced crew complement to perform critical combat tasks (when personnel are attributed through injury and casualties)?

3. MAINTENANCE AND TROUBLESHOOTING - What are the maintenance and troubleshooting requirements that impact on soldier performance of AFV maintenance under a variety of circumstances?

   A. CRITICAL MAINTENANCE TASKS - What are the critical maintenance tasks required to maintain, troubleshoot, and support the AFV?

   B. DENSITY OF ELECTRONIC/VETRONIC EQUIPMENT - To what extent will the density of AFV electronic/vetronic equipment result in maintenance, troubleshooting, and support requirements that exceed the number and cognitive skill of current and projected Army electronic maintenance technicians?

   C. ADEQUACY OF BIT/BITE/ATE - To what extent can BIT/BITE and ATE equipment be used to reliably facilitate the diagnosis of failed subsystems, equipment, or components, and thereby ease the cognitive skill burden on the Army's electronic maintenance technicians?

4. CONTINUOUS OPERATIONS - What are the effects of continuous operations concepts on the ability of AFV personnel to operate, maintain, and support the AFV to achieve combat missions?

   A. CONTINUOUS OPERATIONS MISSION REQUIREMENTS - What are the continuous operations mission requirements for AFV units and what time durations and unit/crew rotations are planned for such missions?

   B. CONTINUOUS OPERATIONS TASKS - What are the critical operations, maintenance, and support tasks which are most adversely affected by the stress and fatigue associated with continuous combat operations?

Table 1. (Cont'd)

2. CONTINUOUS OPERATIONS (Cont'd)

C. CONTINUOUS OPERATIONS PERFORMANCE SHAPING FACTORS - What are the relevant soldier performance shaping factors which most affect performance of critical soldier operations, maintenance, and support tasks and which can be offset through equipment designs which facilitate soldier performance?

D. SOLDIER-MACHINE INTERFACE DESIGN REQUIREMENTS FOR CONTINUOUS OPERATIONS - What are the soldier-machine interface design requirements for enhancing soldier/crew performance of critical AFV tasks during continuous operations?

The specific methodology used by the research team to locate, review, and summarize past research findings and abstract AFV human performance data is presented in the following section.

METHODOLOGY

The basic task of the research staff was to locate, review, and summarize past literature on the four major risk areas identified by the AFV MANPRINT Steering Committee (i.e., encapsulation, information processing, continuous operations, and maintenance).

The Collection Process

The first part of this research project required the location of research material on the four risk areas. As with any literature search in which references from one document lead to the location of other documents, this task progressed throughout the life of the project.

In order to enhance the generalizability and relevancy of results, documents were collected with emphasis on the following four factors:

1) Studies Using Field Experiments. Field experiments provide a means of manipulating meaningful independent measures (e.g., level of MOPP protection) while collecting data on meaningful dependent measures (e.g., number of targets hit) in a realistic setting under semi-controlled conditions. Not all of the studies reviewed, however, were field studies. Often, laboratory experiments, expert judgements, field tests, modelling, simulation, or field observations were found to be useful to the project.

2) Studies Using Soldier Population. With the projected decline in the quality of the military manpower pool (Rimland & Larson, 1980) it was thought probable that the population of soldiers for the AFV would be significantly different, in terms of aptitude and training, from subjects used in many experiments carried out on college populations. These differences could lead

to human performance results which would not generalize between the populations.

3) Studies Using Armored Vehicle Crew Member Tasks. Although it was not known what the exact AFV soldier tasks would be, it was assumed that the tasks would be similar to those performed by present armored vehicle crews. Therefore, studies which involved tasks performed by present armored vehicle crews (e.g., target acquisition, performance in MOPP gear, and command and control performance) were considered important.

4) Studies Containing Quantitative Data. Data which is quantitative in nature can be more easily used to develop specific AFV design and training requirements than can qualitative data. Also, quantitative data are more easily understood by engineers and thus MANPRINT considerations should have a better chance of being incorporated into the system design. Often, however, qualitative data is useful in understanding why or how some phenomenon is occurring and therefore qualitative data were included.

Documents were obtained from a variety of sources with the cooperation of a number of agencies and services. These included the U. S. Army Research Institute (ARI), the U. S. Army Human Engineering Laboratory (HEL), George Mason University, Georgetown University, Defense Technical Information Center (DTIC), Defense Logistics Studies Information Exchange (DLSIE), and National Technical Information Service (NTIS). Documents were also obtained from ARI and HEL scientists as well as from Walter Reed Army Institute of Research (WRAIR) scientists.

The Review Process

The review process commenced with the assessment of each document for relevance to one of the issues. Figure 1 illustrates the decision process used to determine relevance. The assessment tree was developed in accordance with the generalizability factors mentioned above. Although all documents acquired were initially thought to be of possible relevance, upon closer examination many of the documents were not relevant and were not abstracted.

Those documents which survived the initial screening for relevance were categorized as pertaining to one of the four risk areas and each document was given an individual identification (ID) number. The ID numbers began with a two letter sequence identifying the risk area, followed by a three digit number assigned sequentially to the documents as they were reviewed. The ID numbers located on the data collection and summary forms in Appendices B and C can be used later to quickly identify individual documents.

A total of 216 documents were received and reviewed for initial relevance. Of these, 96 were found to be relevant to the AFV and the four risk areas. Twenty-one were relevant to encapsulation, 27 to CONOPS, 28 to information processing and 20 to maintenance. Twenty-four of the studies abstracted were controlled laboratory experiments, 40 were controlled field experiments, and 32 were studies which involved simulation, modelling, expert judgement or observation.

ASSESSMENT TREE FOR RELEVANCE

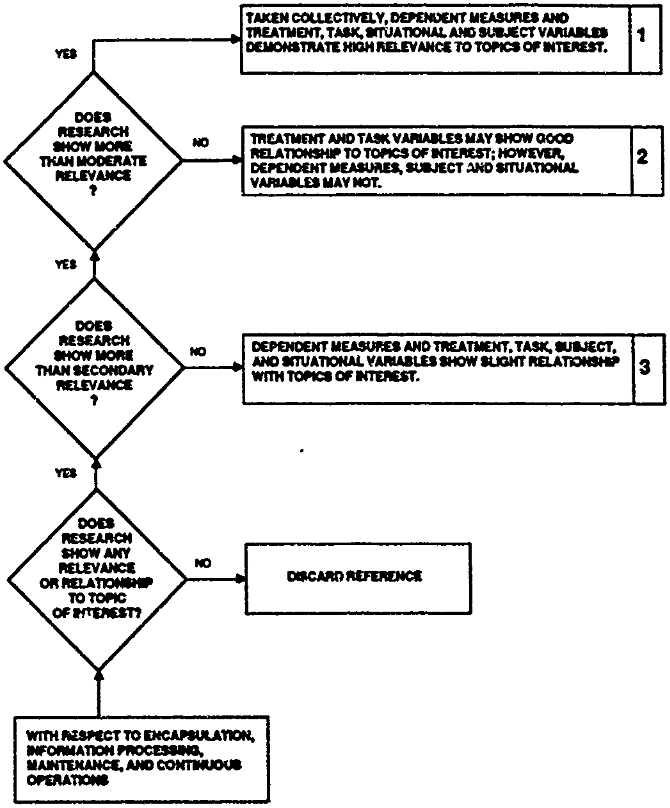


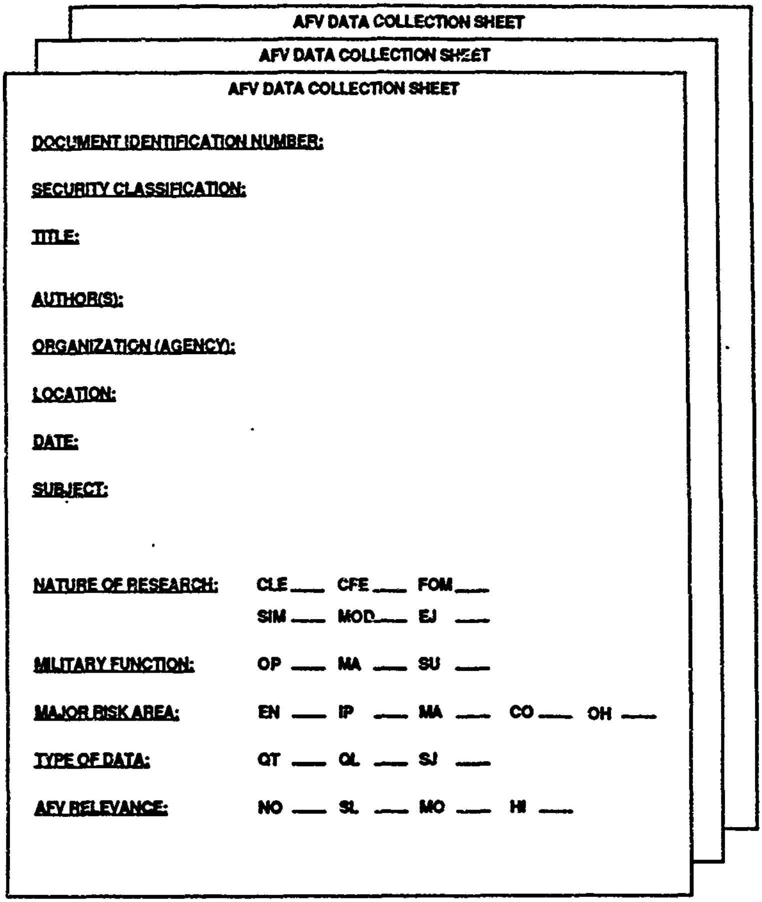
Figure 1. Assessment Tree for Relevance

Following the initial categorization of relevancy, the documents were more thoroughly reviewed. This process consisted of reading and abstracting from the documents quantitative data relevant to one of the four AFV human performance risk areas. In order to assist in the review process as well as organize information obtained from the review, data collection sheets were developed and approved by the STF MANPRINT and ARI Representatives.

The first page of the form, shown in Figure 2, has three basic sections and purposes. In the first section, (at the top of Figure 2) information relevant to identifying the document is presented. This information allows the user to locate the actual document if required. The information entered into this section includes the unique identification number assigned to the document, the security classification, title, and author(s) of the document, the organization and its location, and date of the document.

The second section of the form, "Subject" (shown in the middle of Figure 2), offers a descriptive summary of the research contained in the document and often gives the numbers and types of subjects as well as the manipulations performed. This section provides useful background information which can assist the reader in understanding the research reviewed. The third section of the form, at the bottom of Figure 2, is a checklist describing the research and its relevance to AFV. This includes an indication of the nature of the research, the military function and risk area of the research, the type of data reported, and the AFV relevance (determined from using the relevance decision tree presented as Figure 1). The legend used to interpret the checklist is presented in Figure 3.

The second page of the data sheet, shown in Figure 4, is the AFV Findings/Issues Worksheet. This page has five columns of information. The first column, RISK AREA, contains the document identification number. Relevant research results were placed in the second column, FINDINGS, of the worksheet. Issues abstracted from the findings were placed in the third column, HUMAN PERFORMANCE/MANPRINT ISSUES. These issues required conclusions to be drawn from the findings and implications made for the AFV. A rating of the RELEVANCE of the MANPRINT/Human Performance issue was made in the fourth column. Ratings were based on the Relevance Decision Tree located in Figure 1 (this is the same decision tree used to rate the relevance of the overall document). In the final column, the CRITICALITY of the MANPRINT/Human Performance issue was evaluated. Ratings were performed with the Criticality Decision Tree shown in Figure 5. The decision tree was adapted from the three levels of human factors engineering analysis (HFEA) issues identified in HEL Memorandum number 70-9. Numbers were assigned to the levels and a hierarchical tree was developed.



AFV DATA COLLECTION SHEET

AFV DATA COLLECTION SHEET

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER:

SECURITY CLASSIFICATION:

TITLE:

AUTHOR(S):

ORGANIZATION (AGENCY):

LOCATION:

DATE:

SUBJECT:

NATURE OF RESEARCH: CLE ___ CFE ___ FOM ___
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION: OP ___ MA ___ SU ___

MAJOR RISK AREA: EN ___ IP ___ MA ___ CO ___ OH ___

TYPE OF DATA: QT ___ QL ___ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO ___ HI ___

Figure 2. AFV Data Collection Sheet

LEGEND

CLE	Controlled Laboratory Experiment	CFE	Controlled Field Experiment
FOM	Field Observation or Measurement	SIM	Simulation
MOD	Modelling	EJ	Expert Judgement

OP	Operations	MA	Maintenance	SU	Support
EN	Encapsulation	IP	Information Processing	OH	Other
MA	Maintenance	CO	Continuous Operations		
QT	Quantitative	QU	Qualitative	SJ	Subjective

NO	None	SL	Slight	MO	Moderate	HI	High

Figure 3. AFV Data Collection Legend

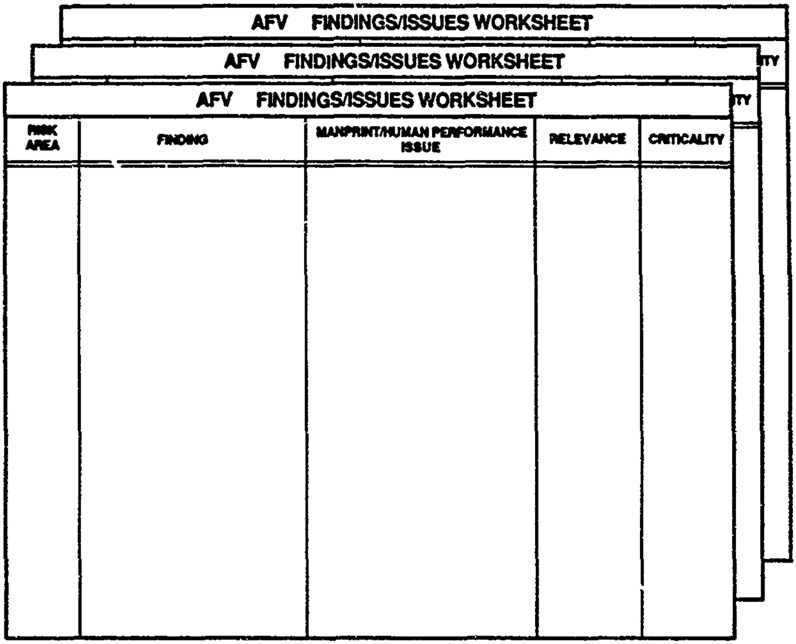


Figure 4. AFV Findings/Issues Worksheet

ASSESSMENT TREE FOR CRITICALITY

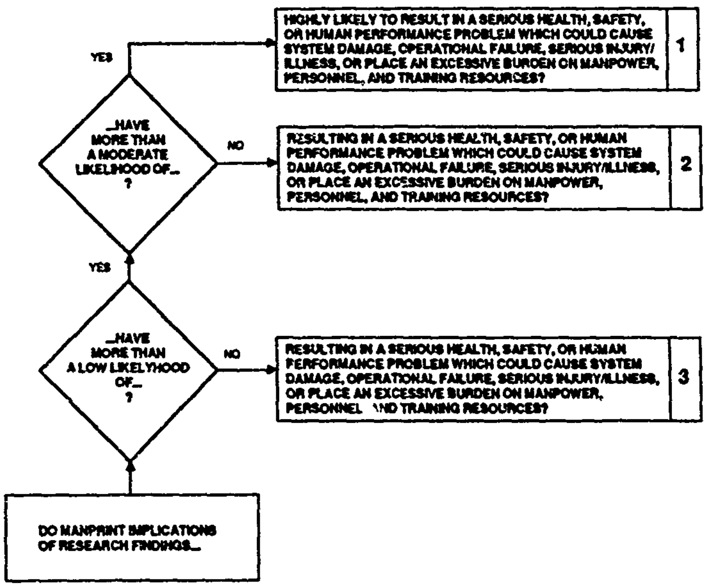


Figure 5. Assessment Tree for Criticality

RESULTS

The purpose of the present project was to collect and abstract from past research information from which human performance MANPRINT implications could be drawn for the AFV in four risk areas. The areas selected by the AFV Manprint Steering Committee were encapsulation, information processing, continuous operations, and maintenance. Presented in the following section are findings relevant to the four areas for the AFV concept. Emphasis was placed on collecting quantitative information which was readily generalizable to both the tasks and population which would use the AFV.

In presenting the results below, each of the four risk areas is treated separately. A definition is provided for each area, followed by a narration of relevant findings. Each section concludes with design, training, and other implications for the AFV. Viewgraphs which parallel the findings and are appropriate for briefings are found in Appendix B. Users who wish more detailed information regarding the findings can refer to Appendix C which contains the abstracted findings and issues for each of the studies reviewed. An alphabetized reference list of all the abstracted documents is located in Appendix A and is cross listed with Appendix C to allow easier access to the information.

Encapsulation

Definition

Encapsulation for the AFV soldier refers to the enclosure and isolation of the soldier from the outside world. For the AFV soldier, encapsulation could occur in the buttoned-up vehicle, in mission-oriented protective posture (MOPP) gear, as well as in both conditions. In the vehicle, the soldier typically has restricted mobility and is in close physical proximity with other crew members. In both the vehicle and MOPP gear, sensory stimulation is attenuated. Of importance to AFV designers will be how encapsulation interacts with environmental stressors such as temperature, noise, and continuous operations in the determination of human performance.

Findings

Humans can be encapsulated for up to 48 hours and possibly much longer with little or no effect on cognitive or perceptual performance (Ormiston & Finkelstein, 1961). For example, submarine crews are often encapsulated for 3 to 6 months with few problems. Reviews of the literature (Kubla & Warnick, 1979) suggest that encapsulation, by itself, does not lead to performance deficits for military crews. A large number of other factors, however, do interact with encapsulation to cause performance deficits. Size and shape of the cabin, the duration of confinement, the work/rest schedules used, the leadership provided, the temperature and noise in the environment, as well as the amount of sensory deprivation or overload experienced by the soldier all interact with encapsulation to degrade performance.

Cabins of small size, when poorly designed, can cause a number of physiological problems which can lead to poor performance. Hicks (1964) found that soldiers who were confined in a mobile or static armored personnel carrier (APC) for varying periods (4-, 8-, 12-, and 24 hours) suffered significant loss of equilibrium, stamina, locomotor coordination, and grenade throwing ability. Deficits were attributed to cramping caused by confinement in a restricted area. The small size of the cabin also provided insufficient space for stowage of equipment, resulting in difficulty entering and exiting the vehicle. Hicks' (1960a, 1964) research suggests that methods should be developed to alleviate cramping and stowage problems in the AFV. Methods to alleviate cramping could include more space to stow equipment, increasing space to allow for exercise, development of exercises which can be performed in close quarters, or development of clothing designed to increase circulation and reduce cramping.

Vibration, caused by moving vehicles, interacts with encapsulation to reduce performance (Hicks, 1960a). Hicks (1960a) found that soldiers confined in a moving APC for 4 hours were affected by nausea, cramping and motion sickness. The result was performance decrements for rail walking, obstructed run, rifle fire, and grenade throwing immediately upon dismounting the vehicle. The above findings have been replicated a number of times (Hicks, 1960b, 1962) and indicate that AFV designs which minimize the effects of cramping and motion sickness can result in superior performance to designs which do not take these factors into consideration.

Soldiers wearing MOPP gear experience a special case of confinement. In MOPP IV the soldier has reduced sensory stimulation (visually, auditorily, and tactually) as well as temperature buildup. During a test (P2NBC2) designed to assess the effects of wearing MOPP gear during extended operations, performance on a number of tasks was found to deteriorate for soldiers in MOPP IV as compared to soldiers in MOPP 0 (Headley et al. 1988). The changes included less accurate use of direct fire weapons, increased calls for direct fire, increased time to perform tasks and missions, increased frequency and duration of radio messages and increased compromises in sound tactical regimen. Soldiers in MOPP IV status also exhibited higher platoon leader losses and replacement times as well as greater friendly personnel and vehicle losses.

Survival times are also greatly affected by the interaction of encapsulation (MOPP IV) and temperature. Tank crews wearing MOPP IV gear in high temperatures lasted from 3.3 to 15 hours (Headley et al. 1988). Similar findings occurred for howitzer crews in MOPP IV in high temperatures. They lasted only 1.9 to 3.8 hours compared to a howitzer crew in MOPP 0 which lasted 19.4 hours. Under mild temperatures, when MOPP gear could occasionally be removed and a sleep break given, Bradley Infantry Fighting Vehicle (BIFV) crews in MOPP IV lasted 31 to 38 hours (Headley et al. 1988). Further, Kelly (1980) found that M1 crewmen dressed in MOPP IV lost effectiveness in 1 hour and 20 minutes while loading and unloading dummy rounds.

Even in MOPP 0, buttoned-up vehicles can reach high and uncomfortable temperatures. Hicks (1964) found that the temperature in an APC with engine off rose to over 100 degrees with relative humidity of 94%. The extreme temperature combined with the restricted space resulted in cramping and nausea which affected performance. Temperature reduction, either by micro or macro cooling, should lead to increased ability to remain encapsulated as well as attenuate performance degradation.

AFV Implications

The above findings indicate that adverse performance effects can occur in an encapsulated environment due to cramping, nausea, and high temperatures. Cramping can be reduced by increasing cabin space which may be accomplished simply by reorganizing the interior. A well-designed cabin can allow for exercise as well as the efficient stowage of equipment. Equipment which cannot be easily stowed can cause accidents if left unstowed in a cramped environment. If additional cabin space cannot be provided for the soldier, devices which allow the soldier to exercise muscles and increase circulation, such as pressure suits, may be useful. Isotonic or other similar exercises may provide relief from cramping.

The nausea soldiers experience while encapsulated in a moving vehicle may be a result of motion sickness. Motion sickness may be reduced if vibration is decreased by developing better suspension systems. Reducing temperature buildup may also decrease the possibility of motion sickness.

High temperatures can be reduced by providing micro and macro cooled environments. Such environments include overpressured tanks as well as micro-cooled vests. Portable cooling units which can be attached to the soldier like a backpack have already been used with success. In Operation REDLEG (U.S. Army Human Engineering Laboratory, 1987), fire direction center (FDC) crews lasted 54 hours with hatches open but with micro-climate systems. With hatches closed and an overpressure macro-climate, FDC crews were able to last 72 hours. The above findings provide powerful evidence to support the idea that reduced temperatures in encapsulated environments will increase survivability.

Methods should also be considered for reducing the humidity buildup in the encapsulated environment. Reduction of humidity will, by itself, reduce the effective temperature providing for better performance. Consideration should be give to the use of a dehumidifier, silica crystals, or other absorbent materials.

Information Processing

Definition

Human information processing refers to the cognitive activity involved in the receipt and analyses of information, as well as the complex decision and action taking which subsequently occur. Some specific information processing characteristics which are important for effective AFV soldier performance include detecting and evaluating (using vision, audition and other senses) degraded information; assessing battlefield cues and situations; and responding to a high workload rate possibly requiring the performance of several tasks simultaneously. The AFV soldier will also have to respond to variable rates of information flow, compensate for variable conditions of mission, enemy, terrain, time available, and troops (METT-T), evaluate and select alternative courses of action, and communicate and coordinate with supporting elements all in a timely manner. The AFV soldier finally may have to compensate for performance decrements resulting from sustained operations (SUSOPS).

Findings

Many of the tasks the AFV soldier will be asked to perform, from the most basic to the most complicated, will require the effective detection and interpretation of information. Much of this information will be in the form of verbal communication. Degraded verbal communication can cause numerous problems for the performance and safety of AFV crews including missed communications, slowed performance, and increased errors. One factor which can cause degraded verbal communication is vehicle noise. Shoemaker, Garinther, and Kalb (1980) tested the effects of vehicle noise on verbal intelligibility for soldiers wearing the DH-132 helmet and AN/VIC intercom system. They found that soldiers could detect 90%, 85% and 70% of the words with background noises of 85 decibels, 95 decibels and 107 decibels respectively. Many of the track vehicles in use today generate noise between 100 db and 115 db when traveling 10 to 20 miles per hour. Methods to reduce verbal degradation due to vehicle noise include improving communication equipment used in the AFV and reducing vehicle noise in the AFV to 95 decibels or lower.

Another factor that can degrade communications is the use of mission oriented protective posture (MOPP) gear. However, Bruno (1979) found that intelligibility between soldiers wearing many different types of masks and hoods was usually adequate (defined by Bruno as above 80% intelligibility). The poorest performance (69% intelligibility) occurred when soldiers wore the M-9A1 mask and the M-3 SP hood.

Although Bruno (1979) found that communications in MOPP gear is adequate under degraded conditions, other sensory information has been found to be degraded by the suits. Both one-handed and two-handed manual dexterity are poorer when wearing nuclear, biological and chemical (NBC) gloves than bare handed (Johnson & Sleeper, 1986). The NBC masks also affect vision. Harrah (1985) found that the field of view decreased between 44% and 58% for soldiers wearing the M17 mask and using binoculars. One of the effects of this was to produce a corresponding increase in scanning time (41% to 69%). To compensate for this, soldiers increased their scanning rate (degrees of area scanned per second) which could possibly lead to missed detection of targets. The XM30 mask was also found to decrease peripheral vision (Barnes, Hanlon, Harrah, & Merkey, 1983). Other problems with this mask included difficulty in correctly donning the mask, and an estimated potential casualty rate of 30% due to early mask removal caused by discomfort. The above problems of reduced sensory input as well as the high fatigue rate associated with heavy work (Poston, 1985) indicate that newly designed NBC equipment is warranted. Improvements to the equipment should be made in the visual and tactile areas as well as heat reduction.

Target detection also plays an important role in information processing and should be considered in the AFV requirements process. The faster targets are detected and identified, the more time is left for decision making and action taking. Typically soldiers are taught to identify targets based on certain salient characteristics. However, in a real situation, the targets will be degraded by distance, shrubs, or other obstacles and the salient characteristics on which the soldier was trained may no longer be visible. A number of studies found that training on degraded targets can greatly improve subsequent degraded target detection (Cockrell, 1979). In one study, target detection for degraded targets improved from 12% after conventional training to 60% when soldiers were trained on degraded targets (Cockrell, 1979). In another study, soldiers identified 46% of camouflaged targets at ranges of 2500 to 3500 meters before training and 90% after training on the degraded targets. Given the great distances over which battle could occur, it will be important for the AFV soldier to be properly trained in the identification of degraded targets. An alternative method to training is to automate target detection and identification. It may be possible to present the soldier with several likely choices of targets. Carefully selected increases in automated devices should reduce human error rates and improve crew performance.

Another factor which interacts with information processing is aptitude level. Scribner, Smith, and Baldwin (1986) found that both gunners and tank commanders (TC) Armed Forces Qualifying Test (AFQT) scores were directly and positively related to the number of targets hit. Wallace (1982) also found that the best predictor of crew gunnery performance was the tank commander's AFQT score. Methods to reduce performance degradation include selecting soldiers with high AFQT scores and designing the AFV to be used by low AFQT soldiers. Designing the AFV to be used by low AFQT soldiers would require the AFV to be easy to use and learn as well as reduce the number and complexity of the decisions which need to be made.

Information processing is also affected by sustained operations. Although the effect of SUSOPS on information processing is covered in the Continuous Operations section of this report, one study should be noted here. Heslegrave and Angus (1985) suggest that previous findings in this area may have underestimated the effects of SUSOPS because the tasks used did not involve continuous cognitive processing. When soldiers perform a number of cognitive tasks continuously over a long period, larger performance deficits are likely to occur than past research has indicated. Heslegrave and Angus (1985) found that serial reaction time and encoding/decoding decreased to 76% and 72% respectively from baseline levels after 24 hours. After 48 hours of continuous work, these values decreased to 43% and 41% respectively. Logical reasoning decreased to 57% of baseline levels after 24 hours and 26% after 48 hours. These values suggest that serious cognitive degradation can occur after only 24 hours work if the work is performed continuously. Methods, such as performance aids or work/rest schedules, should be developed and used in order to reduce the effects of sustained operations on information processing.

There has been a great deal of recent research on the topic of mental workload. Mental workload is an ill-defined concept referring to the degree that a user is busy and consequently processing information. One typical finding is that soldiers required to monitor and detect the firing of different numbers of unattended ground sensors (UGS) were able to detect fewer as the number of sensors increased from 27 (71% detected) to 108 (43% detected) (Edwards, Pilette, Biggs, & Martinek, 1978). Further, as the activity level of the sensors increased there was a corresponding decrease in the number of correct detections (low activity - 74% correct detections, high activity - 40% correct detections). This study and numerous others on mental workload (Wickens, 1984) indicate that as workload increases above some optimal level, performance tends to decrease. Methods to reduce workload, such as providing performance aids in the AFV, should result in increases in performance especially under degraded conditions.

AFV Implications

A number of human performance MANPRINT implications for the AFV can be drawn from the above empirical findings. Improvements in the auditory area of information processing include developing more efficient intercom systems, reducing the noise of the vehicle, and developing standardized hand signals and verbal commands. The field of view should be expanded and distortion reduced for NBC masks. To increase survivability, NBC masks should be made more comfortable, and cooling systems provided. Development of overpressure or sealed vehicles would reduce the time spent in MOPP protection as well as increase the length of time the soldier would be militarily effective. To decrease target detection time, soldiers should be trained on degraded targets, visual enhancement devices which are not affected by smoke, fog or vegetation should be used, and automatic target detection devices which assist in the identification of targets could be developed.

Mission performance could also be enhanced by selecting high aptitude soldiers. For example, it was estimated by Scribner, et al. (1986) that a switch from a 20th percentile tank commander (TC) to a 60th percentile TC would result in a 20% increase in performance. Alternatives to choosing soldiers with high AFQT's include design equipment which is easier to use and automate tasks which are error prone or difficult to perform. Scribner, et al. (1986) estimated that moving to an M1 tank from an M60 would increase crew performance 46.7%. It should be noted that under degraded conditions, the tankers with higher AFQT's may still be able to perform better than tankers with lower AFQT's.

Another method to improve mission performance is to reduce mental workload. Mental workload can be reduced in a variety of ways including the careful design of man/machine interfaces. For instance, for tasks which are primarily verbal, such as instructions, auditory input (e.g., using an earphone) and speech output (e.g., using a microphone) provide good performance (Wickens, Vidulich, & Sandry-Garza, 1984). In using synthesized speech for such a task, response times will be faster if speech rates are relatively high (178 wpm) rather than low (123 wpm). When primarily spatial tasks are performed, such as map reading, visual input (e.g., with a CRT) and manual output (with a joy stick) will usually result in the best performance. For menu selection on a computer display, keyboard entry is superior to joystick selection (Hottman, 1981). The use of human factors principles, such as mentioned above, should greatly reduce the workload placed on an AFV soldier and consequently improve performance, especially under adverse conditions.

Finally, Chambers (1964) identified six information processing mechanisms which under high workload and fatigue lead to degraded performance. Consideration of the factors in the early development of the AFV should reduce human errors and reduce performance degradation under adverse conditions. The first is filtering and refers to the soldier responding to some stimuli but not others. In the second, queing, the soldier may delay making a response during peak workloads. The third effect is approximation and occurs when the soldier takes short cuts, minimally complying with task demands. Stereotyping, the fourth effect, involves the soldier making the same response regardless of the stimulus conditions. The fifth effect is lapses and refers to very short, temporary periods of inattention, sometimes called microsleep. The final effect is omission and occurs when the soldier omits portions of a task. By designing the AFV to minimize the occurrence of these effects as well as the incorporation of the improvements suggested above, human errors should be reduced, safety increased and performance should improve.

Continuous Operations (CONOPS)

Definition

Continuous operations (CONOPS) has been characterized in FM 22-9 as "Combat [which] can and will continue around the clock at the same level of high intensity for extended per.ods." Combat of this type has been made possible by the highly mechanized Army we now have as well as by the technological advances which increase resupply, regrouping and our effectiveness during periods of poor visibility and at night. The new advances envisioned for the AFV should make CONOPS even easier to perform.

A distinction is made between CONOPS and sustained operations (SUSOPS). In SUSOPS, the same soldiers are continuously engaged and have essentially no opportunity to rest. During CONOPS, on the other hand, soldiers may find lulls in the fighting allowing sleep of several hours and the implementation of work/rest schedules. It is possible for CONOPS to involve some SUSOPS.

Findings

A large number of studies have been performed to determine the effects of CONOPS on human performance. Some of the most useful information (although it is specific to SUSOPS performance) for AFV comes from computer simulations of mechanized infantry, armor, and artillery units performed by Siegel and his colleagues (Kopstein, Siegel, Ozkaptan, Dyer, Conn, Sliffer, and Caviness, 1982). The simulations relied on past research findings to provide the manner and amount of performance degradation due to sustained operations. Siegel, Pfeiffer, Kopstein, Wolf, and Ozkaptan (1980) determined from past literature that four factors could be expected to affect performance during SUSOPS. They were fatigue, diurnal rhythm, light level/visibility conditions, and stress. Of the four factors mentioned, fatigue was thought to cause the most degradation and could be expected to affect performance of tasks which involve hearing, numerical facility, orientation, perceptual speed, reasoning and vision.

Using critical task lists and performance degradations found in the literature for the above factors as well as others, Kopstein, et al. (1982) were able to develop performance degradation curves for each crew position of mechanized infantry, armor and artillery units. Figure 6 presents the curves, adapted from FM 22-9. They indicate that performance for positions requiring a large amount of cognitive processing, such as squad leader, will tend to degrade quickly and extensively over time. Performance for positions which are mainly manual in nature, such as a tank loader, will tend to degrade more slowly and less extensively over time.

Effective performance aids should be developed, as suggested by the above findings, to reduce the cognitive demands placed on leaders in order to retard

PROJECTED PERFORMANCE DEGRADATION

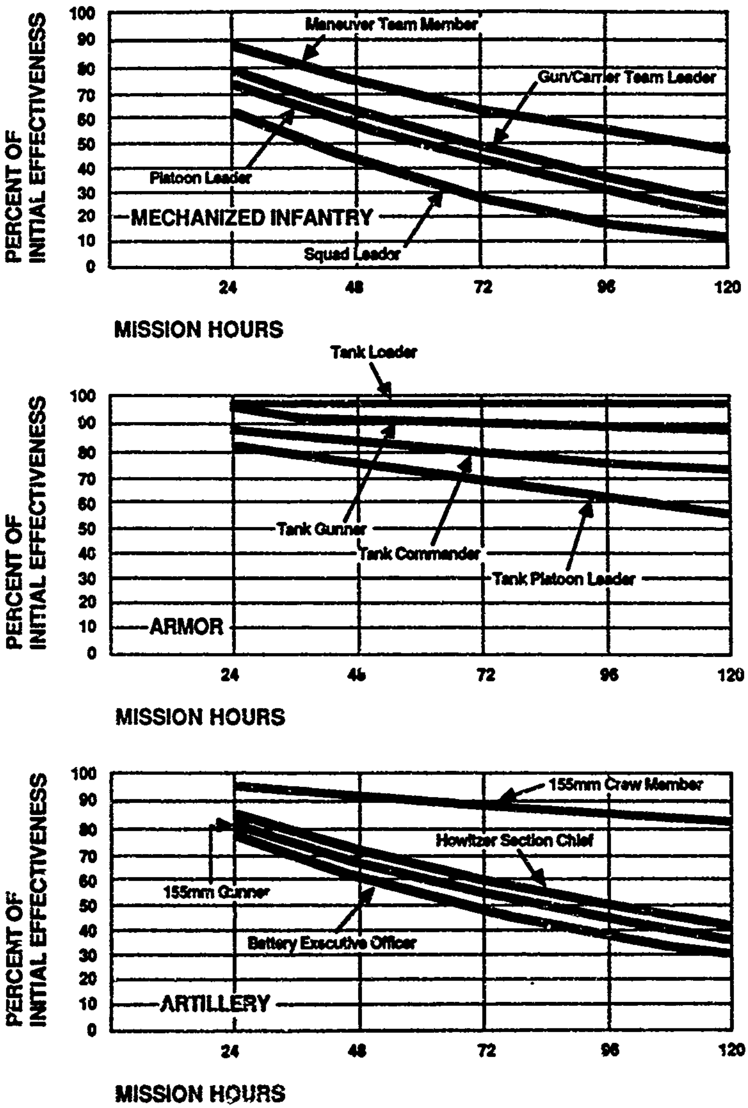


Figure 6. Simulated CONOPS Human Performance Degradation Curves (Adapted From Dept of the Army Field Manual 22-9.)

the degradation effects of SUSOPS. Such aids may include strategies suggested in FM 22-9 such as the use of note pads, check lists and sharing of tasks. The latter was investigated by Siegel, Pfeiffer, Kopstein, Wilson, and Ozkaptan (1979) to determine what method of task sharing was optimal for SUSOPS. They concluded that paralleling of tasks (having two soldiers perform the same tasks) resulted in the most effective performance with task sharing (some steps of a task are carried out by two soldiers) also producing effective performance.

The above findings from computer simulations are based on research results. There appears to be little disagreement in the literature as to what types of performance degrade and how they degrade during CONOPS. The Continuous Operations Study (CONOPS) Final Report (1987) includes an excellent review of CONOPS findings. Studies cited in this report indicate that performance which relies on short term memory, logical reasoning, or encoding/decoding will tend to degrade about 25% for every twenty-four hours of sustained operations (to a low of about 30% of initial performance). For instance, during EARLY CALL I and II (Haslam, 1981) (a British 9-day CONOPS exercise), encoding and decoding performance were found to degrade 23% per day for groups with no sleep.

Several other studies support the above findings (Haslam, 1985). Haslam (1981) also found that rifle assembly performance degraded about 12% per day. The decrease in performance was thought to be due more to the fact that the soldiers had not learned this task well (and thus were relying on short term memory) than to the complexity of the task. The above findings indicate that many tasks required by leaders (e.g., logical reasoning and short term memory) will tend to degrade. Methods for reducing soldier reliance on short term memory as well as decreasing cognitive complexity can help reduce the effects of CONOPS on performance.

Vigilance tasks, such as radar monitoring have also been found to degrade about 25% per day (Siegel, et al., 1979). A vigilance shooting task (Haslam, 1981), which involved detecting and shooting nine targets presented for 5 seconds in 20 minutes, was degraded at the rate of about 15% per 24 hours. Tasks which are boring will tend to degrade. Feedback is one method which may be used to increase one's motivation for a task and thus improve performance.

Banderet, Stokes, Francesconi, Kowal, and Naitoh (1981) tested fire direction center (FDC) units during a SUSOPS exercise. No unit was able to last longer than 48 hours. Unplanned missions were executed accurately. However, the latency with which they were performed increased by 35% within 30 hours. The accuracy for preplanned missions decreased after 24 hours. The errors were caused by omissions, incorrect copying, incorrect setting or reading of scales, and digit reversals. Overall information processing efficiency of the unit decreased by 40% after 42 hours. Communication problems were also found to occur (the number of "say agains" increased from 1 in the first 12 hours to 8 after 24 hours). Performance aids, which force activities to be performed in the correct order and at the correct time, may reduce the number of errors and improve performance. Also, the implementation of work/rest schedules may help extend survivability time and increase information processing speed.

Although a large number of tasks do degrade rapidly during CONOPS, there are also tasks which have been found not to degrade. Generally, tasks which do not have a large cognitive component and tend to be more physical in nature degrade less than cognitive tasks. For instance, performance for driving a 7 ton truck did not degrade for 11 hours of continuous driving (Fuller, 1983). In a 48 hour continuous operations exercise (in which soldiers could get a small amount of sleep) Banks, Sternberg, Farrell, Debrow and Dalhamer (1970) found no degradation for target shooting. Shot grouping capacity also did not degrade (Haslam, 1981). Grenade throwing did not deteriorate over 48 hours (Banks, et al., 1970). And target detection also does not appear to be greatly affected by CONOPS (Banks et al., 1970). This coincides with findings that visual acuity is not affected by CONOPS (Haslam, 1981). However, target detection tasks which contain a large vigilance component can be expected to degrade. Englund, Ryman, Naitoh, and Hodgdon (1985), for example, found a 10% decrease after 24 hours in target detection for a vigilance target detection task.

AFV Implications

A number of implications for the AFV can be drawn from the above studies. There is a large body of evidence to indicate that a number of critical tasks performed by soldiers who are leaders will show rapid and marked deterioration during CONOPS. In order to have a militarily effective AFV crew, it will be important to develop means to retard this degradation. Performance deficits may be reduced by changing the characteristics of the tasks themselves. The Continuous Operations (CONOPS) Study Final Report (1987) suggested that degradation can be retarded if tasks are not of long duration, not cognitively difficult, contain feedback, are well learned, do not require much short term memory, and are intrinsically motivating. The above characteristics should be kept in mind when developing design requirements for the AFV. For instance, monotonous tasks such as radar monitoring could be enhanced by providing feedback and allowing for frequent crew rotations. AFV components should not be overly difficult to learn as well as use. The more difficult a system is to learn how to use, the less likely that it will be learned well and the more likely performance will degrade. Further, tasks should not contain a large number of critically sequenced subtasks. Such a design can result in a large number of errors during CONOPS.

Another method to reduce performance degradation due to CONOPS is to provide the soldier with performance aids. Performance aids include the use of note pads, check lists, cards detailing certain problem solving steps, providing calculators and other devices such as distance estimators which can reduce cognitive load, as well as computers which, after 48 hours, automatically prompt the soldier to perform actions he might have forgotten. Performance aids can be useful to the soldier by reducing the amount of information required to be remembered, forcing a sequence of events to be correctly followed, assisting in decision making by presenting alternatives with possible outcomes, reducing the cognitive complexity of tasks, and reducing errors.

One obvious method to reduce the effects of CONOPS is with sleep. Four hours of sleep in every twenty-four (after 23 hours of deprivation) has been found to be sufficient to eliminate cognitive performance degradation for 5 days (Haslam, 1985). There were no differences in whether this sleep was taken as one 4 hour nap or four one hour naps. Ball, Funk, Noonan, Velasquez, and Konz (1984) essentially confirmed Haslam's (1985) findings. Ball et al. (1984), however, found that map reading and decoding performance degraded slightly after sleep. The drop was due to a recovery period which occurs for about 15 minutes after waking up. Haslam (1985) states that sleep of four hours, no matter how this sleep is broken up, is useful to retard the effects of continuous operations.

Finally, the methods of task sharing and paralleling of tasks may reduce errors during CONOPS. As stated above, these methods involve two or more soldiers each performing either the whole task or part of the task. Both task sharing and paralleling require that soldiers be well cross-trained. Task sharing is more efficient in terms of manpower, but is also slightly more error-prone than paralleling tasks. Both methods greatly reduce errors as compared to single man performance and should be considered for critical task performance during CONOPS. Efficient cross-training of crews will not only allow for task sharing and paralleling during CONOPS, but can also help alleviate the effects of crew turbulence. For instance, Eaton and Neff (1978) found that crews who were cross-trained could hit more targets and generally had better performance than did crews who had not been cross-trained. The suggestions given above as well as others (such as those found in FM 22-9) could be very useful to those involved in the early work on the AFV to reduce the effects of CONOPS on AFV human performance.

Maintenance

Definition

The term, "maintenance", has multiple connotations depending upon the context in which the term occurs. In one context the term may refer to the world-wide network of Army depots; in another, it may refer to replacement of a burned-out lamp. For purposes of this report, "maintenance", is used within the context of MANPRINT. Herein, the term connotes soldier performance of vehicular maintenance tasks. Further, the focus is on organizational maintenance and preventive maintenance checks and services (PMCS) performed by the vehicle operator or crew. Under the "maintenance" heading, are also discussed those factors, such as aptitude and training, which shape performance as well as the equipment and situational features which impact specific task performance. Maintenance record keeping, parts supply, and other administrative aspects of the total maintenance process are not covered in this discussion.

Findings

The institutional training of organizational maintenance personnel took them only to the apprenticeship level and many critical tasks were omitted from institutional training and were left to OJT (United States General Accounting Office, 1987a). Vehicle crewmen received little training in preventive maintenance checks and services (PMCS) and arrived at the unit knowing little about PMCS (Fuller, Rugge, and Harris, 1984). Fuller, et al., also found that the military units they studied neither conducted nor scheduled on the job training (OJT) for organizational maintenance or for operator and crew PMCS. It should be noted that Harper, Simpson, Fuller and Harris (1981) showed that efforts directed toward increasing skills of maintenance personnel in the unit were effective in improving maintenance and were well worth the effort.

When unsupervised, PMCS was often not done or was done improperly (Actkinson, 1978). This was corroborated by Fuller, et al. (1984) who found that the "before-operation" PMCS was done most frequently. The "during-operation" and "after-operation" PMCS was rarely done unless a breakdown occurred. They also observed that PMCS time was frequently used to repair existing malfunctions rather than in preventing malfunctions.

Kern and Hayes (1983) discovered that in most organizational maintenance shops, even the inexperienced mechanics were usually unsupervised and received no corrective feedback on their work. The shops they studied had no quality control inspection or supervisory checks of completed work. The mechanic was the sole judge of when the task was completed. Of the mechanics they observed, 71% left serious uncorrected errors in repair work that required special tools or technical specifications. Many of the mechanics were unaware that technical specifications were required. For repairs not requiring special tools or specifications, 22% of the mechanics still left serious errors uncorrected. Fuller, et al. confirmed another finding by Kern and Hayes that technical manuals (TMs) and checklists are not routinely used by either operators or mechanics who depend instead upon their memory or consult someone else. Kern and Hayes note that experience "stamps in" past performance as the standard and, indeed, they found that experienced mechanics do not differ from the inexperienced in level of skill and efficiency. Both made about the same number and type of errors. The consequences and generality of this state of affairs were confirmed in a recent document (United States General Accounting Office, 1987a) which reviewed inspection reports on 5,539 tracked and wheeled vehicles and found that 50% of the vehicles had been placed in "in-operable" status.

Relatively simple equipment design features are still impeding maintenance performance. Earl and Crumley (1985) found fasteners, latches, handles and hold-down divides on the MLRS which were difficult to release and refasten and in one instance were a hazard to the maintainer. They also reported problems with drain plugs and access for repairs and for cable connections. The latter also represented problems on the M1 Tank (AMC Materiel Readiness Support Activity, 1984).

Fault diagnostic equipment much as Automatic Test Equipment (ATE), Built In Test Equipment (BITE), and Test, Measurement, and Diagnostic Equipment (TMDE) has generally failed to meet expectations. Test data reviewed by the General Accounting Office (1987b) showed that fault isolation to one line-replacable-unit (LRU) was 15% whereas the design goal was 90%. In the same test, false removals reached 54% whereas the goal was 7%. Better results were reported for the Patriot system when fault detection reached 88% (goal was 99%) and fault isolation reached 62% (goal was 75%) (General Accounting Office, 1987b). The Simplified Test Equipment for the M1 Tank (STE-M1) was reported to be successful 52% of the time that it was used, with a reliability of 81% (Material Readiness Support Activity, 1984). However, Marcus and Kaplan (1984) report that the set was used on only 3% of the occasions on which it could have been used. Further, they found that its use consumed, on average, 6 hours per maintenance incident rather than the 4 hours specified as a goal. The General Accounting Office (1987b) confirmed these difficulties with the STE-M1 and reported that Army actions to overcome test set shortfalls and improve troubleshooting will cost over $78 million.

Rouse and Hunt (1986) explored several aspects of human problem solving performance within a troubleshooting context. They found that "cognitive style" (as measured by the Matching Familiar Figures Test and the Embedded Figures Test) predicted problem solving ability better than did "ability" and "aptitude" after minimum standards of ability and aptitude were met. Impulsive subjects made the most errors and impulsivity was not compensated for with practice. The best problem solvers were the reflective, field-independent subjects. They also concluded that while human problem solving tends to be highly context-specific, humans can be taught general problem solving skills which transfer to specific situations. A further finding was that humans have trouble making maximum use of the information available in troubleshooting tasks and computerized aids can improve performance in this situation.

The impact of MOPP gear on maintenance performance depends upon the task being performed (Waugh and Kilduf, 1984). Conditions up to and including MOPP 4 did not increase time to perform an "easy" task (the TOW self-test). On the other hand, for the "difficult" repair (Dragon night sight), use of the mask/hood and gloves increased repair time by 18% and wearing MOPP IV resulted in a 45% in time.

Successful organizational maintenance, according to a General Accounting Office report (1987a) was characterized by local command emphasis on maintenance, supervision of PMCS, sufficient training in PMCS for operators and first-line supervisors, and sufficient parts, tools, publications, personnel and time devoted to maintenance.

AFV Implications

The review of this sample of reports on maintenance performance leads to several clear implications for the AFV program. The results highlight the importance of integrating ILS and detailed requirements for fault diagnostic equipment into the acquisition from it's earliest stages. This integration must extend to the "MANPRINTING" of fault diagnostic equipment itself and its interface with other components of the total system. The importance and the ramifications of designing for ease of maintenance (providing access, simplicity, markings, warnings, durability, single point connections and reducing special tools) are repeatedly emphasized by the results. Designing the AFV for ease of maintenance and avoiding as much as possible the need for special tools will payoff in better PMCS, more effective maintenance, and better training. Much of the proper design can be achieved by adhering to existing human engineering standards, guidelines and checklists.

In the training area, the results point to two areas for attention. First, the institutional maintenance training program should include training in the use of system specific fault diagnostic equipment. This implies furnishing sufficient equipment to the school for training purposes. Second, the system training program should provide unit OJT in maintenance. The requirements for bringing this to fruition within the units must be considered in preparing the QQPRI and, ultimately, must be reflected in the unit TOE. Another matter impacting TOE has to do with achieving a higher level of maintenance effectiveness with existing levels of resources. The information regarding the efficiency and effectiveness of present vehicular maintenance practice strongly suggests that worthwhile improvements are possible through quality control and supervisory inspection of repairs. It is no doubt an oversimplification to suggest that the number of mechanics might be reduced, in order to free personnel spaces for maintenance supervisors. The point is that the potential benefits recommend the issue for serious scrutiny. It is also important that QQPRI take into account the entire functioning system for each AFV variant. Failure to do so can lead to unexpected manpower requirements in fielding the system as occurred with MLRS where 246 additional spaces were required for 26 MLRS batteries (Arabian, Hartel, Kaplan, Markus and Promisel, 1984).

Finally, taken together, the findings are a resounding reaffirmation of the need for MANPRINT and a total system approach to materiel acquisition. They repeatedly demonstrate the impact on maintenance of the interaction and interdependence of hardware design, training, manpower, personnel, and safety issues. There is no dearth of illustrations of the complexity, delay and ultimate cost of failing to integrate these considerations beginning in the earliest stages of the materiel acquisition process.

DISCUSSION

The discussion section will focus on some of the research voids identified from the above findings as well as provide suggestions for future research. The research voids discussed here should not be considered the only voids which exist. Rather, they are general areas which the authors identified as important and for which little or no research was found. The suggested future research needs follow logically from the voids and can provide the basis for developing new research programs. More specific research voids and needs were discussed as AFV implications in the results section of this report.

One of the most obvious and crucial research voids is the lack of critical tasks for AFV soldier performance. Development of a data base, such as this, relies on the collection of relevant information. However, without a critical task list, one can only guess at the relevant AFV human performance MANPRINT issues and needs. Development of a critical tasks list will enable guided research to occur which can result in useful information relevant to the AFV. This requires that a thorough job and task analysis be performed for all crew positions for all AFV variants.

Critical task lists also enable the determination of crew size, workload levels and soldier/machine function allocation. These factors are vitally important to the entire development of the system. Once task lists have been developed, relevant past literature, some of which is presented in this document, may be used to assist in the function allocation. Also, future research may be directed to determining the crew size requirements, workload levels and the allocation policies for the AFV.

The second research void is concerned with the factors affecting human performance. One of the findings of encapsulation is that encapsulation, by itself, does not appear to cause degraded performance. Rather, it is the interaction of encapsulation with other factors which leads to performance problems. Human performance is the end result of complex interactions of a number of variables. However, many of these interactions have never been tested and their impact on military performance have not been assessed. For instance, it is not known what the effects of high workload in an encapsulated environment are or how training can affect workload.

Past research has focused on questions of the form, "How is performance affected by variable X?" Answers to these types of questions are important and should be addressed. However, there is little research directed at answering questions such as, "How is military performance affected by the interactions of different lengths of continuous operations, encapsulation, temperature, and workload?" Questions such as these are difficult to answer with typical field studies. What may be required is the development of models of human performance under each of the conditions separately, and then computer simulation of the interaction of these models. This could be accomplished by developing a data base which contains quantified research relevant to the AFV. The data base could then be used to develop models and functions of AFV human behavior. Validation of the results through one or two carefully designed field studies would then allow the AFV designer to conduct tradeoff analyses via computer to determine the optimal crew size and function allocation.

Another research void is concerned with continuous operations. Although a great deal is known about the types of performance which degrade during CONOPS, there is little empirical evidence on methods of retarding the degradation. FM 22-9 offers a number of excellent suggestions for reducing the effects of continuous operations on military performance. However, many, if not most of these methods have never been tested to assess their effectiveness. The fast and extreme degradation of cognitive functioning indicates that anything that can assist and reduce the workload and information processing required by the soldier can reduce degradation. Some of these methods will have design implications for the AFV such as the determination of the type of information to display on a cathode ray tube (CRT), how it is displayed, and what types of tasks should be automated. Future research should examine methods which reduce these factors and determine which designs offer the most cost efficient means of reducing degradation.

Little is known about special characteristics or aptitudes required by the AFV soldier. After a critical task list is developed, trade-off studies can be performed to determine the optimal category of soldier aptitude and special characteristics to select from. Determination of these factors will be important in developing the design for the AFV. Selection of soldiers with lower AFQT scores will necessitate AFV designs which produce performance unaffected by aptitude. Development of such a vehicle suggests that special attention be paid to automating tasks requiring higher aptitudes. Emphasis should then be placed on reducing complicated tasks as well as considering training and maintenance needs.

The design of the AFV offers special challenges in the area of training. There are many questions and little information on this topic. For instance, because the vehicles will have so many similar parts, can driving be taught at one place to all drivers? Should embedded training systems be used in the vehicles? And how should maintainers be trained? Future research should be directed at determining the place of advanced training techniques in the AFV concept.

This limited review did not uncover information on several questions regarding maintenance which would seem important. For example, what are the conditions under which maintenance tasks will likely be performed in the airland battle environment? How will the fix-forward concept shape the maintainer's job? How can the full potential of the ATE concept be realized? Can changes in maintenance management alone result in significant improvements in maintenance effectiveness?

That the subject of maintenance is much studied at all levels became clear in making this brief examination of existing information. Therefore caution is in order before asserting that there are information voids or areas needing research. However, based on the results of this examination, the following are suggested as topics needing exploration:

a. Fault diagnostic test set engineering.

b. The reduction of the false removals of serviceable parts.

c. The detection and diagnosis of intermittent faults.

d. How to specify the requirements for fault diagnostic equipment.

e. Achieving a higher level of performance proficiency on the part of the individual mechanic. Potential approaches include changes in institutional training, OJT, management and supervision, job aiding and use of technical specifications.

Summary

Review of this sample of 96 documents has uncovered information potentially useful in the AFV MANPRINT programs. This report presents that information in a form designed to meet the needs of the user while providing a clear audit trail back to the original research for those interested in more detailed data. It is not possible to give a precise measure of the total universe of research from which this sample is drawn; it is certainly much larger than the sample. On the other hand, the scope of the search which led to this sample of documents warrants the confident assertion that this sample is characteristic of the total body of research. Further examination of existing literature should continue to furnish additional information useful in the AFV program, but that information is not likely to contradict information presented here.

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APPENDIX A

AFV HUMAN PERFORMANCE

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APPENDIX B

AFV HUMAN PERFORMANCE

BRIEFING INPUT

The following material may be used as briefing input for human performance issues related to the AFV. The results section of the report provides a source of narration to aid in preparing viewgraphs. The first chart summarizes the number and types of documents received and reviewed. The next chart briefly summarizes relevant findings from each of the four risk areas. Definitions and relevant findings of a more detailed nature for each of the four risk areas are presented in the next thirty pages (7 or 8 per risk area). Located at the bottom left hand corner of the pages are the document ID numbers from which the information was obtained. The ID numbers can be used to obtain more detailed information than what is presented. Finally, two charts with some identified research voids and future research needs are presented.

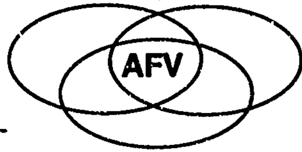
AFV SOLDIER PERFORMANCE REFERENCES

	STATUS	CONTROLLED LABORATORY EXPERIMENTS	CONTROLLED FIELD EXPERIMENTS	OBSERVATIONS, SIMULATION, MODELLING, EXPERT JUDGEMENTS	TEST BEDS
AFV SOLDIER PERFORMANCE AREAS (ENCAPSULATION, CONTINUOUS OPERATIONS, INFORMATION PROCESSING, MAINTENANCE)	REVIEWED AND DISCARDED	19	45	56	REDLEG P2 NBC2 ENDURE EARLY CALL I EARLY CALL II TANK TEST BED
	ABSTRACTED	24	40	32	

TOTAL REFERENCES REVIEWED TO DATE - 216

ABSTRACTED TO DATE - 96

SOLDIER PERFORMANCE RESULTS



ENCAPSULATION

- ENCAPSULATED VEHICLE CLIMATE RELATED TO CREW ENDURANCE
- RESTRICTED MOVEMENT CAN IMPEDE PSYCHOMOTOR SKILLS
- DURATION OF CONFINEMENT UP TO 48 HOURS SHOWS MINIMAL ADVERSE EFFECTS
- FULL MOPP LEVEL RESULTS IN PERFORMANCE PROBLEMS AND DECREMENTS

CONTINUOUS OPERATIONS

- PERFORMANCE DECLINES FOR ALL CREW POSITIONS
- GREATEST DECLINES EXHIBITED BY SQUAD AND PLATOON LEADERS
- COMPLEX COGNITIVE SKILLS DECLINE FIRST, FOLLOWED BY MOTOR SKILLS
- SELF-PACED ACTIVITIES SHOW GREATEST DECLINE WITH ERRORS OF OMISSION MOST COMMON

INFORMATION PROCESSING

- VISUAL MONITORING PERFORMANCE DECLINES AS WORKLOAD INCREASES
- TASKS OF LONG DURATION AND COMPLEX ATTENTION SEQUENCES LEAD TO PERFORMANCE DECREMENTS UNDER CONDITIONS OF SLEEP LOSS
- VEHICLE NOISE ADVERSELY IMPACTS VERBAL COMMUNICATION AMONG CREW
- LACK OF TRAINING ON DEGRADED TARGETS IMPEDES TARGET IDENTIFICATION
- TANK CREW PERFORMANCE DECLINES AS SOLDIER APTITUDE DECLINES

MAINTENANCE

- FAILURE TO IMPLEMENT ILS EARLY LEADS TO SUBSEQUENT MAINTENANCE DIFFICULTIES
- CRITICAL MAINTENANCE TASKS OFTEN NOT IDENTIFIED
- PERFORMANCE OF FAULT DIAGNOSTIC EQUIPMENT GENERALLY DISAPPOINTING
- 33% OF REPAIR TIME AND DOWN TIME IS DUE TO FALSE REMOVALS

Salient Characteristics of Encapsulation

-- Sealed Cabin

-- Restricted Mobility

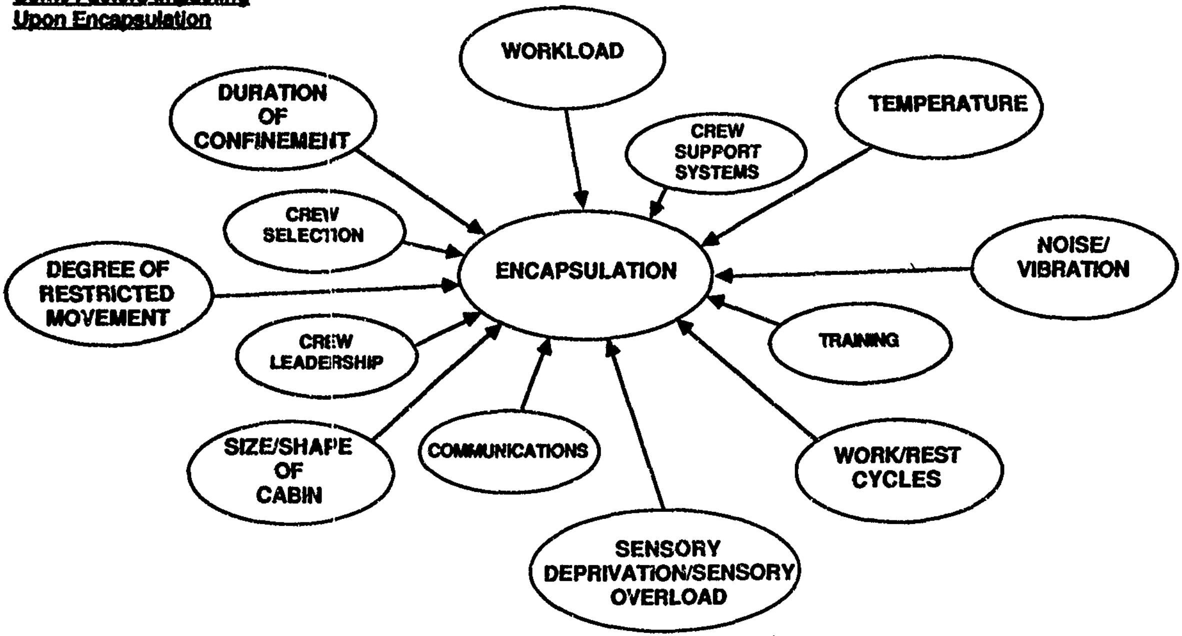
-- Reduced Sensory Stimulation

-- Crew Physical Proximity

-- Continuous or Sustained Operations

-- Environmental Stressors (Temperature, Noise, Vibration)

Some Factors Impacting
Upon Encapsulation



Encapsulation

Issue: What are the effects of encapsulation on crew performance?

Findings: Encapsulation by itself does not appear to lead to performance decrements with military crews. Instead performance decrements are reported when other factors are present (e.g., high temperature, sleep loss, restricted movement) during periods of confinement.

AFV Implication: Determine other factors that co-vary with AFV encapsulation that have an impact on crew performance.

Encapsulation

Issue: What other factors present during vehicle encapsulation have an impact on crew performance?

Findings:

High Temperature - Tank crews in MOPP 4 lasted 3.3 to 15 hours.

- Howitzer crews in MOPP 4 lasted 1.9 to 3.8 hours compared to a MOPP 0 condition lasting 19.4 hours.

Mild Temperature - Under mild temperatures, frequent exposure to outside air, and a sleep break, BIFV crews in MOPP 4 lasted 31 to 38 hours.

Micro Climate - In open hatch, comtaminated, micro climate, FDC crew performed tasks for 54 hours.

Macro Climate - In closed hatch, over pressure, macro climate, FDC crew performed for 72 hours.

AFV Implication: Climate control within encapsulated vehicles has a direct bearing on how long crews can perform.

EN 021

Encapsulation

Issue: What other factors present during vehicle encapsulation have an impact on crew performance?

Findings: Restricted Movement

- Infantrymen confined for 12 hours in a stationary APC show significant loss of equilibrium, stamina, locomotor coordination, and grenade throwing accuracy. Decrements attributed to cramping.
- Insufficient space to stow equipment interfered with entering and leaving vehicle.

AFV Implication: Interior space configuration while maintaining adequate soldier movement are important AFV design issues.

EN 006, EN 009

Encapsulation

Issue: What other factors present during vehicle encapsulation have an impact on crew performance?

Findings: Duration of Confinement

- Confinement for 48 hours does not have adverse effects on standard measures of intellectual and perceptual functioning. Some studies show decrements for visual monitoring tasks in unchanging environments, but most decrements are considered transitory.
- Some individuals with low tolerance for confinement will defect.

AFV Implication: Although confinement in armored vehicles has not been studied extensively, mini-exercises, rest cycles, and stimulus change events may offset any visual monitoring decrements resulting from prolonged performance periods.

EN 016, EN 017

<u>Encapsulation</u>

Issue: What other factors present during vehicle encapsulation have an impact on crew performance?

Findings: MOPP Gear - Placing troops in full MOPP status results in numerous performance problems and decrements:

-- Less accurate use of direct fire weapons
-- Increased calls for indirect fire
-- Increased time to perform tasks/missions
-- Greater friendly personnel and vehicle losses
-- High platoon leader losses and replacement times
-- Increased frequency and duration of radio messages
-- Increased compromises in sound tactical regimen

AFV Implication: A vehicle environment allowing troops to remain in as low a MOPP level as possible is desirable.

EN 020

Salient Characteristics of Information Processing

-- Assess Situation

-- Respond to High Cognitve Workload

-- Perform Several Tasks Simultaneously

-- Evaluate Degraded Information

-- Respond to Variable Rates of Information Flow

-- Compensate for Variable Conditions of METT-T

-- Evaluate and Select Alternative Courses of Action

-- Communicate and Coordinate with Supporting Elements

-- Execute Tasks in a Timely Manner

-- Compensate Performance Decrements resulting from Sustained Operations

Information Processing

Issue: What are the effects of sustained mental work on cognitive performance in a command and control environment?

Findings: Percentage of effective performance from baseline for different cognitive tasks after first and second night of sleep loss is shown below:

	Percent Effective Responses From Baseline	
	After 24 Hours	After 48 Hours
Serial Reaction Time	76%	43%
Encoding/Decoding	72%	41%
Logical Reasoning	57%	26%

AFV Implication: Since the present study focused on the effects of continuous cognitive work, previous findings may underestimate the effect of sustained cognitive workload in a high-intensity, information rich, command and control environment.

IP 003

Information Processing

Issue: What factors affect target detection?

Findings: The percentage of targets detected both before and after the implementation of several different types of training methods waqs found to be:

Percent of Targets Detected Before and After Training

Type of Training	Before	After
Long Range Identification of Targets	62%	98%
Long Range Camouflage Detection	46%	90%
Different Views of Degraded Targets	12%	60%

Other findings of interest:

- o The M17 mask decreases the field of view between 44% and 58%.
- o The M17 mask increases scanning time between 41% and 69%.
- o The XM30 mask decreases visibility and peripheral vision.
- o A 33% casualty rate was estimated for soldiers wearing the XM30 mask from mask removal resulting from discomfort.

AFV Implications: Consideration should be given to training soldiers on long range, camouflaged, or otherwise degraded vehicles. Improving the field of view for protective masks may also be useful in improving target detection performance. Improving the comfort of the masks may increase survivability.

IP 007, IP 008, IP 009, IP 028

Information Processing

Issue: How are verbal communications affected by vehicle noise?

Findings: Percentages of words correctly perceived by soldiers using the DH-132 crew helmet and AN/VIC intercom while being subjected to simulated noise levels of common track vehicles are shown below:

Sound Level db(A)	Percent Of Words Correctly Perceived
107db	69.9%
95db	85.0%
85db	90.3%

The figures below can be used for comparison of the above findings.

Sound Level db(A) of Track Vehicles at Different Speeds

	Type of Vehicle				
Speed (mph)	M1	M60A1	M107	M109A1	M113A1
10	94db	98db	110db	108db	103db
20	104db	100db	115db	109db	107db

AFV Implications: Since vehicle noise reduces the amount of verbally presented information which can be understood using current intercom systems, development of more efficient communication devices or the reduction of vehicle noise should be considered.

IP 015

Information Processing

Issue: What is the effect of aptitude on performance?

Findings:

o The best predictor of crew gunnery performance was the tank commanders (TC) AFQT score.

o Simulations of confrontations between Blue and Red forces with TC's of different AFQT category levels (CAT) showed the following:

o When TC's in the Blue forces and in the Red forces were CAT II soldiers, the tank kill ratio is 7.45 : 1 in favor of the blue forces.

o With the Red forces' TC as a CAT II and the Blue forces TC a CAT IV, the kill ratio drops to 1.33 : 1.

o It has been estimated that a switch from a CAT IV tank gunner and TC will yield approximately a 20.3% increase in performance.

AFV Implications: Crew performance can be enhanced by selecting higher AFQT soldiers. Consideration should also be given to designing the AFV to enable high performance from lower AFQT soldiers.

IP 022, IP 024

Information Processing

Issue: How does workload affect monitoring performance?

Findings: The percentages of targets detected for men monitoring different numbers of unattended ground sensors (UGS) as well as different levels of activities of the sensors are:

	Number of Sensors		
Activity Level	27	54	108
Low	85%	76%	60%
High	56%	39%	26%

AFV Implications: As workload increases, monitoring performance tends to decrease. Consideration should be given to developing means to reduce monitoring workload such as having a computer summarize data, adding more observers or training for high workload.

IP 011

Information Processing

Issue: What aspects of cognitive tasks show differential sensitivity to the effects of sleep loss as would ocurr in sustained operations?

Findings: The performance impact that sleep loss has on different aspects of cognitive tasks is presented below:

Aspect of Task	Performance Decrement Is Facilitated	Performance Decrement Is Retarded
Tasks of long duration	X	
Tasks of high cognitive difficulty	X	
Tasks for which feedback is given		X
Tasks which are well practiced		X
Tasks with complex attention sequences	X	
Tasks involving short term memory	X	
Tasks with work/rest cycles		X
Tasks of high intrinsic interest		X

AFV Implication: Vehicle controls and displays should be designed which minimize the necessity for crews to perform tasks of long duration, high difficulty level, complex attention sequences, and reliance on short term memory. Where possible, implement procedures which retard performance decrements.

IP 002

Information Processing

Issue: What are the effects of excessive workload and fatigue on cognitive functioning in a command and control environment?

Findings: Investigators have identified the following adverse effects of excessive workload and fatigue.

Filtering	- Subject systematically responds to some stimuli, but not others.
Queuing	- Subjects delays making responses during peak loads.
Approximation	- Subject takes shortcuts; minimally complies with task demands.
Stereotyping	- Regardless of stimulus conditions, subject tends to make the same response.
Lapses	- Temporary periods where subject ceases to process information, sometimes called microsleeps.
Omission	- Subject omits portions of a task.

AFV Implication: Design of vehicle displays and controls for reducing information processing requirements of crew deserves foremost consideration.

IP 014

Salient Characteristics of Continuous Operations

Continuous Operations (CONOPS)

-- Combat Occurring Around the Clock

-- Some Opportunity for Sleep using Work/Rest Schedules

-- May Contain Periods of Sustained Operations

-- Reduced Visibility During Night Operations

Sustained Operations (SUSOPS)

-- Same Soldiers Engage in Continuous Operations

-- Little Opportunity to Stand Down

-- Little Opportunity for Rest or Sleep

Continuous Operations

Issue: How long can mechanized infantry soldiers perform in sustained operations?

Findings: Findings are from computer simulations of degraded military effectiveness ratings with 100% equaling un-degraded baseline performance (e.g. 65% indicates the soldier is 65% as effective as he was before SUSOPS).

	Projected Percent Effective from Baseline=100% 24 hours	48 hours	72 hours
Mechanized Infantry			
Squad leader	65%	45%	30%
Platoon leader	75%	60%	45%
Gunner/carrier team leader	80%	65%	50%
Maneuver team member	85%	75%	65%

AFV Implications: Performance deficits which occur during SUSOPS may be reduced by applying the strategies suggested by FM 22-9 (e.g. cross training crews, using check lists and note pads, sharing and cross checking tasks, among others).

CO 003

<u>Continuous Operations</u>

Issue: How long can armor soldiers perform in sustained operations?

Findings: Findings are from computer simulations of degraded military effectiveness ratings with 100% equaling undegraded baseline performance (e.g. 65% indicates the soldier is 65% as effective as he was before SUSOPS).

	Projected Percent Effective from Baseline=100% 24 hours	48 hours	72 hours
Armor			
Tank platoon leader	85%	75%	65%
Tank commander	90%	80%	75%
Tank gunner	100%	90%	90%
Tank loader	100%	99%	99%

AFV Implications: Estimates of military effectiveness indicate that projected tank crew performance should be less affected by SUSOPS than mechanized infantry performance.

CO 003

Continuous Operations

Issue: How long can artillery soldiers perform in sustained operations?

Findings: Findings are from computer simulations of degraded military effectiveness ratings with 100% equaling undegraded baseline performance (e.g. 65% indicates the soldier is 65% as effective as he was before SUSOPS).

	Percent Effective from Baseline=100%		
	24 hours	48 hours	72 hours
Artillery			
Battery executive officer	80%	60%	50%
155mm gunner	85%	70%	50%
Howitzer section chief	85%	70%	60%
155mm crew member	95%	90%	90%

AFV Implications: Performance deficits which occur during SUSOPS may be reduced by applying the strategies suggested by FM 22-9 (e.g. cross training crews, using check lists and note pads, sharing and cross checking tasks, among others).

CO 003

Continuous Operations

Issue: What tasks will be affected and how will they be affected by continuous operations?

Findings: Percentages are approximate and indicate the percentage of degradation from 100% baseline performance which was found to occur for every 24 hours in controlled laboratory or field experiments.

Tasks Which Do Not Degrade	Tasks Which Do Degrade (Approximate percent degraded from 100% baseline every 24 hours)
• Shot Grouping Capacity	• Vigilance Shooting - 15%
• Target Shooting	• Rifle Assembly - 12%
• Rifle Loading	• Decoding/Encoding - 25%
• Target Detection	• Logical Reasoning - 25%
• Visual Acuity	• Short Term Memory - 25%
• Driving	• Vigilance - 25%

AFV Implications: To reduce these performance deficits, consider suggestions in FM 22-9 such as providing memory and decision aids, adequate training, cross training of crews, paralleling or task sharing, and at least 3 hours of rest every 24 hours.

CO 008, CO 009, CO 011, CO 012, CO 014, CO 016

Continuous Operations

Issue: How will Fire Direction Center (FDC) teams be affected by continuous operations?

Findings:

- FDC teams will be able to last around 45 to 48 hours during CONOPS.
- Preplanned rather than unplanned mission accuracy will be degraded.
- Unplanned mission latency will degrade 35% after 30 to 42 hours into CONOPS.
- Accuracy for self paced activities such as those in preplanned missions, rather than forced paced activities will degrade.
  - Errors of ommission, incorrect copying, incorrect setting or reading of scales, and digit reversals will be most common.
  - Requests for 'say again' increased from 1 to 12 after 24 hours.
- The rate at which information can be processed by artillery teams drops between 30% and 40% after 42 hours and can drop another 20% within 8 more hours.

AFV Implications: Develop means to force pace activities after 24 hours. Provide memory and decision aids as well as develop efficient methods of communication. Cross train crews and use paralleling or task sharing, and at least some rest every 24 hours.

CO 017

Continuous Operations

Issue: What are the effects of crew turbulence on tank gunnery performance?

Findings:

- o Position familiarity plays a reliable part in reducing opening time on Table VIII gunnery exercises. It is also related to an increase in the number of targets hit.

- o Generally, crews in unfamiliar crew positions performed much more poorly than those in comparable crews who were familiar with their duties.

AFV Implications: Since crew turbulence may be unavoidable, consideration should be given to cross training, within units, for acquisition of gunnery skills.

CO 027

Salient Characteristics of Maintenance

-- Focus on PMCS and Organizational Maintenance

-- Mechanical and Electronic Systems

-- Fault Diagnostics

-- LRUs, Spare Parts

- Removal/Replacement

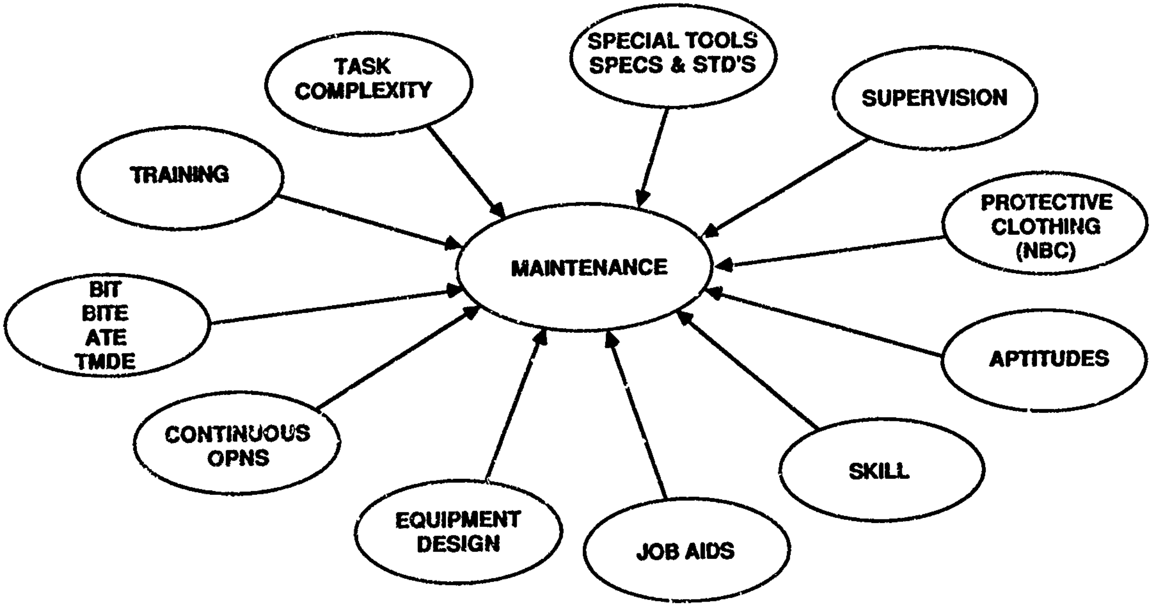
-- Maintenance training (Institutional and OJT)

-- Supervision/Maintenance quality control

-- Design for ease of maintenance

-- Precision/Tolerance

Some Factors Impacting
Upon Performance of Maintenance Tasks



Maintenance

Issue: How effective is the present maintenance system?

Findings:

Inspections of 5,539 wheeled and tracked vehicles placed 50% in "in-operable" status.

37% to 47% of howitzer and M578 recovery vehicle failures were due to improper maintenance or human failure.

Troubleshooting was the number one weakness of organizational maintenance personnel.

False removals - - - - - - 42% to 54%
Average time to identify false removal. - - - - - - 1.5 hr.
Percent of total repair time spent identifying false removals - - - 32%
Percent of vehicle down time due to false removals - - - 30%

For repairs requiring special tools or technical specifications (ST/TS), 71% of mechanics left one or more serious errors uncorrected.

For repairs not requiring ST/TS, 22% of mechanics left one or more serious errors uncorrected.

66% of mechanics either failed to perform the required checkout after repair or performed it incorrectly.

Successful maintenance operations are characterized by:

a. Local command emphasis on maintenance
b. Supervision of PMCS
c. Sufficient operator and first-line supervisor PMCS training
d. Sufficient parts, tooks, publications, personnel and time devoted to maintenance

AFV Implication: Significant gains in AFV availability and mission performance can be achieved through improvements in the maintenance system. AFV commonality should facilitate maintenance.

MA 005, MA 006, MA 013, MA 014, MA 017

Maintenance

Issue: What are the effects of equipment design features on maintenance performance?

Findings: Simple design features contribute to maintenance difficulties.

a. Fasteners, latches, handles and hold-down devices are not always designed for safe and easy release and refastening.

b. Drain plugs and overflows are not always provided where needed or are inadequate.

c. Access for repairs and for cable connections is often inadequate.

d. Removal and replacement of the main gun mount and rotor, removal and replacement of the traversing mechanism, and removal and replacement of the powerpack on the M1 are inherently hazardous maintenance operations due to the handling of very heavy items in very limited space.

AFV Implication: In AFV acquisition use, as appropriate, existing standards and specifications much as MIL-STD-1472, Human Engineering Design Criteria for Military Systems; MIL-H-46855, Human Engineering Requirements for Military Systems, Equipment and Facilities; MIL-HDBK-743, Anthropometry of US Military Personnel; MIL-HDBK-759, Human Factors Engineering for Army Materiel; and MIL-HDBK-761, Human Engineering Guidelines for Management Information Systems. For topics not adequately covered by the above consider checklists and lessons learned contained in various HEL and ARI documents as source material for RFP requirement statements. Specific examples are MA 009, MA 015, MA 016 in Appendix C.

MA 005, MA 015, MA 039

B-30

Maintenance

Issue: What are the effects of training on maintenance performance?

Findings: Institutional training trains M1 tank mechanics in only 29% of the critical tasks, enough for apprenticeship. Balance is to be learned in OJT.

PMCS was covered only briefly in operator AIT.

Typically, no maintenance training for operators or crews is done by the units, nor is any shown on the training schedules.

Experienced vehicle mechanics do not differ from the inexperienced in level of skill and efficiency exhibited during performance and both are equally likely to leave serious errors uncorrected. Mistakes are perpetuated through lack of corrective feedback.

Efforts directed toward increasing the skills of maintenance personnel in the unit effectively improve maintenance and are well worth the effort.

AFV Implication: Consider the requirements for maintenance training, including maintenance training devices and simulators in the AFV training package. Unit OJT may be an element worth including in the AFV training program.

MA 001, MA 005, MA 006, MA 013, MA 020

Maintenance

Issue: What are the effects of personnel aptitudes and abilities on maintenance performance?

Findings: "Cognitive style" was a much better predictor of problem solving ability than ability and aptitude after minimum standards of ability and aptitude were met. Impulsive subjects made the most errors and impulsivity was not compensated for with practice. Reflective, field-independents were the best problem solvers.

Human problem solving tends to be highly context-specific. However, humans can be taught general problem solving skills which transfer to specific situations.

Humans have trouble making maximums use of the available information. Computerized aids can improve human performance.

Force required for pushing with a single thumb in the horizontal or vertical downward directions should not exceed 25 pounds for males. (e.g.: inserting circuit boards in electronic equipment.)

AFV implication: These findings emphasize the need to design equipment for ease and simplicity of maintenance.

MA 003, MA 011

Maintenance

Issue: What factors affect the use of fault diagnostic equipment?

Findings: BITE Performance

MLRS	Goal	Independent Tester	Project Office
Fault isolation to one LRU	90%	15%	No data
Maximum False removals	7%	54%	8%

Pershing

Test Director	Correct Diagnosis
Contractor	96%
"	88%
Independent	59%

Patriot	Goal	Actual
Fault detection	99%	88%
Fault isolation	75%	62%

M1 Tank Fault diagnostics

Actions to overcome test set shortfalls and improve troubleshooting will cost over $78 million. STE-M1 showed a success rate of 52% with 81% reliability. Test set used only 3% of the time. Test set cumbersome and too time consuming to use. Cables and circuit boards were frequent sources of test set malfunction.

AFV Implications: Fault diagnostic equipment should be an integral part of materiel design early in the acquisition process. Fault diagnostic equipment itself should be "MANPRINTED". Training in its use should be part of the system training program. Document MA 004 contains a checklist which may be useful in preparing RFP requirements for AFV diagnostic equipment.

MA 002, MA 005, MA 007

<u>Maintenance</u>

Issue: What other factors affect maintenance performance.

Findings:

MOPP Gear –

Conditions up to and including MOPP4 did not increase time to perform "easy" task (TOW self-test).

MOPP4 increased repair time for "difficult" task (Dragon night sight) by 45%.

Mask/hood and gloves increased time by 18% on "difficult" task.

Supervision –

Crew PMCS often not done or done improperly.

Of 285 inspection reports analyzed, 64% cited failure to complete or record daily PMCS and 35% cited failure to schedule or perform periodic servicing.

Technical Specifications/ Special Tools –

TM's were used by 13% of the mechanics performing tasks requiring use of TM.

75% of operators had a TM for their equipment. Many TM's were not up to date or were not the proper version for the equipment on-hand.

Both operators and mechanics rely on memory or consult others rather than the TM. Many tasks require reference to technical specifications.

Special tools tend to be "unavailable".

AFV Implications: Design for ease of maintenance and keep special tools to the minimum. Consider marking parts that require reference to technical specifications. Emphasize PMCS in training program.

MA 006, MA 010, MA 012, MA 013, MA 020

AFV SOLDIER PERFORMANCE INFORMATION VOIDS

- IMPACT OF HUMAN PERFORMANCE VARIABLES ACTING COLLECTIVELY IN A SIMULATED TACTICAL ENVIRONMENT
- PERFORMANCE OF MAINTENANCE TASKS IN AIRLAND BATTLE ENVIRONMENT
  - REACHING THE FULL POTENTIAL OF THE ATE CONCEPT
  - ACHIEVING A HIGHER LEVEL OF PERFORMANCE PROFICIENCY
- IDENTIFICATION OF CRITICAL TASK LISTS, WORKLOAD, CREW SIZE, AND SOLDIER/MACHINE FUNCTION ALLOCATION
- DETERMINATION OF AFV SOLDIER APTITUDES AND SPECIAL CHARACTERISTICS
- DETERMINATION OF INTEGRATED TRAINING APPROACHES TO AFV

POTENTIAL AREAS FOR AFV SOLDIER PERFORMANCE RESEARCH

- CONDUCT DIRECTED RESEARCH (e.g., SIMULATIONS, MODELLING) ON IMPACT OF HUMAN PERFORMANCE VARIABLES ACTING COLLECTIVELY
- EXPLORE HOW THE FIX-FORWARD CONCEPT SHAPES THE MAINTAINER'S JOB
- EXPLORE REALISTIC APPROACHES TO IMPROVING MAINTENANCE TASK PERFORMANCE
- EXPLORE FEASIBILITY OF ADVANCED TRAINING TECHNOLOGY (e.g., EMBEDDED TRAINING)
- PERFORM JOB/TASK ANALYSIS FOR ALL CREW POSITIONS (FOR ALL AFV VARIANTS)
- EXPLORE SYSTEM DESIGNS THAT ENHANCE PERFORMANCE-SUSTAINING TECHNIQUES RELEVANT TO CONTINOUS OPERATIONS
- CONDUCT TRADE-OFF STUDIES ON AFV CREW APTITUDES AND SPECIAL CHARACTERISTICS

APPENDIX C

AFV HUMAN PERFORMANCE

DATA SHEETS

The following data base can be used to obtain detailed information regarding the reviewed documents. The documents are arranged by document ID number (located at the top of the Data Collection Sheet and referred to in the Risk Area column of the Findings and Issues Worksheet) within each of the four risk areas. Encapsulation is presented first followed by information processing, continuous operations and finally maintenance. The legends as well as more detailed information used to interpret the data sheets can be found in the methods section of this report.

ENCAPSULATION (EN)

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 001

SECURITY CLASSIFICATION: Unclassified

TITLE: 72 hour REDLEG P2NBC2 FDC Evaluation.

AUTHOR(S):

ORGANIZATION (AGENCY): U.S. Army Human Engineering Laboratory.

LOCATION: Aberdeen Proving Ground, MD.

DATE: 1987

SUBJECT: Results of the 72 hour REDLEG P2NBC2 FDC Evaluation. Study evaluated Fire Direction Center crew's ability to operate for 72 hours in an NBC environment. Crews operated under two conditions: closed hatch over pressure (macro climate) and open hatch contaminated (micro climate).

NATURE OF RESEARCH:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN _X_	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT _X_	QL _X_	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI _X_	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 001	1.1 Crew performed combat tasks for entire 72 hour scenario under macro climate condition. 1.2 Crew performed combat tasks for 54 hours before test was halted under micro condition.	Micro climate and macro climate vehicle environments have a direct bearing on how long crews can function effectively under NBC conditions.	1	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 002

SECURITY CLASSIFICATION: Unclassified

TITLE: Road battalion operations in a toxic environment. Vol I of III. Operational capability experiment.

AUTHOR(S):

ORGANIZATION (AGENCY): Combat Development Command Experimentation Center, (CDCEC, 63-4)

LOCATION Fort Ord, CA

DATE. December, 1963

SUBJECT: Operational capability of a unit operating "buttoned-up" in MOPP gear under conditions of high temperature.

NATURE OF RESEARCH: CTE ___ CFE _X_ FOM ___
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION OP _X_ MA ___ SU ___

MAJOR RISK AREA IN _X_ IP ___ MA ___ CO ___ OH ___

TYPE OF DATA QT _X_ QL _X_ SJ ___

AFV RELEVANCE ND ___ SL ___ MO ___ HI _X_

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EX 002	2.1 Infantrymen were able to operate efficiently for only 20 minutes in temperatures of 75° to 90°F where high energy expenditure levels are required in mission-oriented, protective posture (MOPP).	Given this type of finding, is it reasonable to expect soldiers to effectively accomplish combat missions in MOPP gear, as presently designed, under conditions of moderate to high temperature?	|	|

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 003

SECURITY CLASSIFICATION: Unclassified

TITLE: Memorandum to CG, SUBJECT: XM1 testing in a chemical environment.

AUTHOR(S): MAJ Kelly

ORGANIZATION (AGENCY): DCSCD/NBC Directorate.

LOCATION: U.S. Army Proving Grounds, Yuma, Arizona

DATE: September, 1980

SUBJECT: The effects of a tank crew (XM1) fighting buttoned-up in full MOPP ensemble under high temperature conditions. M1 Crewmen, with hatches closed, blowers off, and fully clothed in MOPP 4 gear, simulated firing the main gun by loading and unloading a dummy round and traversing and elevating the turret.

NATURE OF RESEARCH: CLE ___ CFE _X_ FOM ___
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION: OP _X_ MA ___ SU ___

MAJOR RISK AREA: EN _X_ IP ___ MA ___ CO ___ OH ___

TYPE OF DATA: QT _X_ QL _X_ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO ___ HI _X_

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 003	3.1 Crew lost effectiveness after 1 hour and 20 minutes; the test was terminated when temperature was 102°F.	Close monitoring of NBC conditions to minimize the necessity of high MOPP levels may potentially alleviate the adverse effects of operating buttoned-up.	1	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 004

SECURITY CLASSIFICATION: Unclassified

TITLE: Work Schedules and performance during confinement, Human Factors, 10,143-195

AUTHOR(S): W.D. Chiles, E.A. Alluisi, O.S. Adams

ORGANIZATION (AGENCY):

LOCATION:

DATE: 1968

SUBJECT: Report covers an 8-year program of research on the performance effects of required work/rest schedules during confinement to a simulated aerospace vehicle crew compartment.

NATURE OF RESEARCH:	CLE X	CFE ___	FOM ___		
	SIM ___	MOD ___	CJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EM X	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 004	Four primary issues were examined: (1) How many crew members are required to maintain around-the-clock operations for a given number of work positions? (2) What is the optimum duration of the duty period for performing such work? (3) How many days can such performance be maintained without decrement? and (4) Which work/rest schedules appear to be optimum in the sense they have the least impact on the crew member's performance reserves?			
	4.1) It was found that two men can handle 24 man-hours of work per day very satisfactorily, even on a long-term basis (i.e., 30 days).	These findings give rise to the need to identify the number of man-hours per 24 hour period that each AFV variant will require across the durations of their representative missions. These estimates, in turn, will help to determine crew size.	2	2
	4.2) Three men can handle 48 man-hours of work per day for periods of 15 days if the likelihood of an additional stressor is low.			
	4.3) With tasks that are not intrinsically interesting the briefer work periods (i.e., 4 hours) are preferred, and subjects generally predicted that duty periods longer than 4 hours would lead to decrements.			

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 004	4.4) In terms of levels of performance maintained, the 4/4 work/rest schedule with confinement was no more demanding than a normal 8 hour, split-shift work day without confinement. 4.5) Given that performance reserves after following a particular schedule are defined in terms of the impact on performance of 2 days without sleep, it was found that a 4/4 schedule had substantially fewer deleterious effects on performance reserves than did 16 hours of work per day on a 4/2 schedule. NOTE: Authors warn that the goodness of fit of these findings to other systems is too highly dependent upon the specifics to permit generalized statements.	Taking into account the tasks that will be performed by crewmembers, further consideration and research is needed on optimal work/rest cycles during periods of the mission which permit rest/work cycles.		

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 005

SECURITY CLASSIFICATION: Unclassified

TITLE: Effects of isolation on man's performance

AUTHOR(S):

ORGANIZATION (AGENCY): Bioengineering and Cabin Ecology, Science and Technology Series, American Astronautical Society.

LOCATION: Torzana, California

DATE: 1969

SUBJECT: Review of the confinement and isolation literature.

NATURE OF RESEARCH:	CLE ___	CFE X	FOM X		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN X	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT ___	QL X	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 005	From a review of the confinement and isolation literature, Sells and Rawls (1969) reported three rather consistent findings:			
	5.1 "status leveling" as a result of confinement whereby a lack of privacy and social distance between subordinates and superiors tends to blur subordinate-superior relationships and undermines authority -- all confined members tend to become the same in terms of status.	These findings have leadership implications more than they do vehicle/equipment design ramifications. Whenever a long period of confinement is anticipated, leaders must take command and clearly state rules for conduct for use of contrained space and other limited resources. At the same time, leaders should be tolerant of harmless efforts by crew members to "personalized" their own cramped quarters (e.g., affixing a photograph to an over-head structure).	3	2
	5.2 anger, scorn, and ridicule are directed toward superior authorities outside the confined group, and			
	5.3 an increase in territorial behavior -- individuals jealously guard their personal possessions or a particular location or item of furniture in an enclosed shelter. Hammes and Osborne (1963) also observed territorial behavior among personnel in fallout shelters.			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 006

SECURITY CLASSIFICATION: Unclassified

TITLE: The effects of confinement on the performance of combat relevant skills: Summary report.

AUTHOR(S): S.A. Hicks

ORGANIZATION (AGENCY): U.S. Army Engineering Laboratory (Technical Memorandum 16-64).

LOCATION: Aberdeen Proving Ground, MD.

DATE: December 1964

SUBJECT: Extended research program included a total of 277 enlisted men confined in a mobile or static APC for varying periods of time (4-,8-,12-, 24-hours, and for 12-hour periods for each of five successive days) under varying conditions (open hatch closed hatch). Before and after confinement, subjects took tests of stamina, response time, gross motor coordination, arm steadiness, equilibrium, and eye-arm coordination. The tests included rail walking, reaction time, hand-steadiness, equilibrium, obstructed run, rifle firing, grenade throwing, and 220-yard running course.

NATURE OF RESEARCH:	CLE ___	CFE X	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN X	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL X	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 006	Certain factors were cited as especially likely to cause performance decrements: 6.1 Vehicle configuration causes body cramping and, consequently, loss of lower-extremity circulation. 6.2 Backrests were uncomfortable because they pressed into the small of the back and kidney area.	NOTE: Author cautions that studies did not fully simulate the extreme conditions of combat (e.g., driver's hatch was open allowing for better vision and ventilation) and thus results must be interpreted cautiously. Changes in variables which interact with confinement may have drastically different effects than reported here. With respect to the conditions studied, the effects of long-term confinement on the performance of infantry personnel were considered relatively transient. While decrements were demonstrated for single periods of confinement, they become positively smaller after repeated confinements. It was the author's belief that detrimental effects could be offset through repeated practice of the tasks to be performed and through repeated exposure to the confinement situation before deployment.	1	1
	6.3 The radio rack, mounted on the side wall of the vehicle, irritated the back and neck of the passenger who occupied that station. 6.4 Some 20-30 percent of personnel reported nausea during their first confinement.			

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 006	6.5 Temperature and humidity rose steadily to 101 degrees F and 94 percent relative humidity -- very uncomfortable -- even with the vehicle's engine off. 6.6 Insufficient tie-downs and space to stow equipment; equipment interfered with entering and leaving vehicle. 6.7 Water vapor collected on the vehicle's interior surfaces, wetting clothing and rusting equipment.			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 007

SECURITY CLASSIFICATION. Unclassified

TITLE: The effects of four hours confinement in mobile armored personnel carriers on selected combat relevant skills: A pilot study.

AUTHOR(S): S. A. Hicks

ORGANIZATION (AGENCY): U. S. Army Human Engineering Laboratory (Technical Memorandum 3-60)

LOCATION: Aberdeen Proving Ground, MD

DATE: 1960

SUBJECT: The study determined the way four hours' confinement in a moving armored personnel carrier affects performance on psychomotor tasks related to basic infantry skills-rail walking, obstructed run, rifle fire and grenade throwing.

NATURE OF RESEARCH:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN _X_	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT _X_	QL _X_	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI _X_	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 007	7.1 Four-hour confinement produced losses in all areas, with a significant loss in firing accuracy and impairment of equilibrium.		2	1
	7.2 An important factor degrading performance was the feeling of nausea that a number of subjects reported.	Investigate guidelines and corrective actions for minimizing motion sickness.		
	7.3 Frequent complaint was the limited space which caused cramping and loss of circulation to lower part of body.	The design trend toward smaller and lighter vehicles may augment soldier cramping and loss of circulation in the lower part of the body.		

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 008

SECURITY CLASSIFICATION: Unclassified

TITLE: The effects of eight hours confinement in mobile armored personnel carriers on selected combat relevant skills: Study II

AUTHOR(S): S. A. Hicks

ORGANIZATION (AGENCY): U. S. Army Human Engineering Laboratory (Technical Memorandum 17-60)

LOCATION: Aberdeen Proving Ground, MD

DATE: 1960

SUBJECT: The study determined the way eight hours' confinement in a moving armored personnel carrier affects performance on psychomotor tasks related to basic infantry skills-rail walking, obstructed run, rifle firing and grenade throwing both before and after confinement.

NATURE OF RESEARCH:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN _X_	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT _X_	QL _X_	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI _X_	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 008	8.1 There was a significant loss in stamina and gross-motor coordination.		2	1
	8.2 Equilibrium was slightly impaired.	Investigate guidelines and corrective actions for minimizing motion sickness.		
	8.3 Soldiers suffered from nausea and cramping.	The design trend toward smaller and lighter vehicles may augment soldier cramping and loss of circulation in the lower part of the body.		

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 009

SECURITY CLASSIFICATION: Unclassified

TITLE: The effects of twelve hours confinement in static armored personnal carriers on selected combat relevant skills: Study III

AUTHOR(S): S. A. Hicks

ORGANIZATION (AGENCY): U. S. Army Human Engineering laboratory (Technical Memorandum 1-61)

LOCATION: Aberdeen Proving Ground, MD

DATE: 1961

SUBJECT: The study determined the way twelve hours' confinement in a static armored personnel carrier affects performance on psychomotor tasks related to basic infantry skills.

NATURE OF RESEARCH:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN _X_	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT _X_	QL _X_	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI _X_	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 009	9.1 After confinement, subjects showed a significant loss of equilibrium, stamina, locomotor coordination, and grenade-throwing accuracy. There was no change in rifle-firing accuracy.	Observed decrements were attributed to cramping resulting from the size and configuration of the vehicle, (motion, vibration, and noise were absent). Interior space and configuration limitations while maintaining adequate soldier habitability will be key design issues for AFV.	2	1
	9.2 After 12 hours of confinement in an APC, interior of vehicle became hot, damp, cluttered and dirty.			

AFV DATA COLLECTION SHEET

__DOCUMENT IDENTIFICATION NUMBER__: EN 010

__SECURITY CLASSIFICATION__: Unclassified

__TITLE__: The effects of twelve hours confinement in mobile armored personn- carriers on selected combat relevant skills: Study IV

__AUTHOR(S)__: S. A. Hicks

__ORGANIZATION (AGENCY)__: U. S. Army Human Engineering Laboratory (Technical Memorandum 2-61)

__LOCATION__: Aberdeen Proving Ground, MD

__DATE__: 1961

__SUBJECT__: The study determined the way twelve hours' confinement in mobile armored personnel carriers affects performance on psychomotor tasks related to basic infantry skills.

__NATURE OF RESEARCH__:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
__MILITARY FUNCTION__:	OP _X_	MA ___	SU ___		
__MAJOR RISK AREA__:	EN _X_	IP ___	MA ___	CO ___	OH ___
__TYPE OF DATA__:	QT _X_	QL _X_	SJ ___		
__AFV RELEVANCE__:	NO ___	SL ___	MO ___	HI _X_	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 010	10.1 The 12 hour confinement resulted in significant losses in stamina and locomotor coordination.	Consideration needs to be given to guidelines and countermeasures for minimizing these losses.	2	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 011

SECURITY CLASSIFICATION: Unclassified

TITLE:

AUTHOR(S): S. A. Hicks

ORGANIZATION (AGENCY): U. S. Army Human Engineering Laboratory (Technical Memorandum 23-61)

LOCATION: Aberdeen Proving Ground, MD

DATE: 1961

SUBJECT: The study investigated the effects of confinement in APCs on various combat relevant tasks; period of confinement was for 24 hours.

NATURE OF RESEARCH: CLE ___ CFE _X_ FOM ___
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION: OP _X_ MA ___ SU ___

MAJOR RISK AREA: EN _X_ IP ___ MA ___ CO ___ OH ___

TYPE OF DATA: QT _X_ QL _X_ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO ___ HI _X_

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 011	11.1 Approximately half the subjects performed as well after confinement as before it. 11.2 A significant loss in eye-arm coordination and hand-arm steadiness was evidenced. 11.3 Twenty-three out of 44 subjects did not complete the study. A potential confounding exists because those subjects remaining had more room to move about and to secure comfortable positions for sleeping and relaxing.	Guidelines designed to offset psychomotor losses may be worthwhile.	2	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 012

SECURITY CLASSIFICATION: Unclassified

TITLE: The effects of twenty-four hours confinement in mobile armored personnel carriers on selected combat relevant skills: A follow up.

AUTHOR(S): S. A. Hicks

ORGANIZATION (AGENCY): U. S. Army Human Engineering Laboratory (Technical Memorandum 7-62)

LOCATION: Aberdeen Proving Ground, MD

DATE: 1962

SUBJECT: The investigation studied how confining subjects in maneuvering armored personnel carriers for 24 hours affects stamina, eye arm coordination, locomotion coordination, equilibrium, and hand-arm readiness.

NATURE OF RESEARCH:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU _·_		
MAJOR RISK AREA:	EN _X_	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT _X_	QL _X_	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI _X_	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 012	12.1 Significant losses occurred in all areas except eye-arm coordination (grenade-throwing accuracy).		2	1
	12.2 Duffel bags and equipment obstructed exit from the vehicle. After 24 hours, floors were cluttered with wasted rations, ration cans, and broken relief bags that complicated an already overwhelming and nauseous odor.	Efficient stowing of equipment is a vehicle design issue that deserves attention.		
	12.3 During periods of maximum condensation, moisture dripped down, wetting clothing/blankets and rusting equipment. In addition, commander's vision blocks fogged up.	Training in some basic procedures for prolonged habitability may eliminate some of the clutter problems. Use of deodorants may mask offensive odors. Ventilation may offset water vapor problems.		

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 013

SECURITY CLASSIFICATION: Unclassified

TITLE: The effects of repeated confinement on the performance of men in a hot-wet climate.

AUTHOR(S): S.A. Hicks

ORGANIZATION (AGENCY): U.S. Army Human Engineering Laboratory (Technical Memorandum 7-63)

LOCATION: Aberdeen Proving Ground, MD.

DATE: 1963

SUBJECT: A single group of subjects was confined repeatedly to hot-wet environment (summer in Panama) after first being acclimatized to heat. Eleven men were confined on alternate days for a total of 16 confinement sessions. Treatment conditions were: six hours open hatch, mobile; four hours closed hatch, mobile; six hours closed hatch, mobile; and six hours closed hatch, static. Before and after confinement, subjects took tests on choice reaction time, hand steadiness, equilibrium, and 220-yard running speed.

NATURE OF RESEARCH:	CLE ___	CFE X	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	FN X	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 013	Repeated confinement in a wet-hot environment produced:			
	13.1 Significant impairment of hand steadiness.	The use of countermeasures (e.g., isometric exercises) to mitigate performance losses deserves consideration.	2	1
	13.2 Significant impairment of running speed.			
	13.3 Significant decrement in equilibrium.			
	13.4 No effect on choice reaction time.			
	13.5 With each criterion measure, the decrement was largest after the initial exposure to the treatment variable.			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 014

SECURITY CLASSIFICATION: Unclassified

TITLE: The effects of repeated confinement on the performance of men in a temperate environment

AUTHOR(S): S. A. Hicks

ORGANIZATION (AGENCY): U. S. Army Human Engineering Laboratory (Technical Memorandum 16-64)

LOCATION: Aberdeen Proving Ground, MD

DATE: 1964

SUBJECT: Study examined the effects of confining a group of subjects in a mobil APC repeatedly, for 12 hour periods on each of five successive days. Tests consisted of equilibrium, stamina, gross motor coordination, and markmanship.

NATURE OF RESEARCH:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN _X_	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT _X_	QL _X_	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI _X_	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 014	14.1 There were significant losses in all areas after the initial confinement period.	Results suggest that subjects appear to adapt after repeated confinements. It should be kept in mind, however, that subjects had a complete night of rest between each of the five successive test days. How much adaptation would occur under the erratic work/rest cycles typical under combat conditions remains an empirical issue.	2	1
	14.2 Subsequent confinements showed progressively smaller decrements; after the final (fifth) confinement, subjects performed at the pre-confinement level.			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 015

SECURITY CLASSIFICATION: Unclassified

TITLE: Human factors in mechanized warfare Oxford, England: Brassey's Publishers Limited

AUTHOR(S). Richard E Simpkin

ORGANIZATION (AGENCY):

LOCATION: Oxford, England

DATE: 1983

SUBJECT: Based on General Simpkin's own experience, this book presents little data, but contains interesting and unorthodox insights into human performance characteristics from the tanker's rather than the system designer's perspective. The book is divided into three major parts: Living, Servicing, and Fighting.

NATURE OF RESEARCH: CLE _X_ CFE ___ FOM ___
SIM ___ MJO ___ EJ ___

MILITARY FUNCTION: OP _X_ MA ___ SU ___

MAJOR RISK AREA: EN _X_ IP ___ MA ___ CO ___ CH ___

TYPE OF DATA: QT ___ QL _X_ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO _X_ HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 015	The following quotations were taken from Chapter 4, Waiting Periods Under NBC Threat, of Simpkin's Human Factors in Mechanized Warfare.			
	15.1 Modesty - "So modesty is a prime requirement, comprehending minimization of physical exposure, privacy in urination and defecation, suppression or localization of the odors of these processes and swift, private disposal of the products".	How are human waste products to be disposed of during periods of prolonged confinement?	2	1
	15.2 Boredom - "Boredom will evidently be a major and psychologically dangerous problem. Back in the previous chapter I proposed including an auto-type radio/cassette player to help relaxation during moves. . . . a tuner/converter unit could put color television onto the monitor/display unit which will inevitably form a part of each crew station".	How can slack or down time be profitably utilized during confinement?		
	15.3 Training - "Training would at once alleviate boredom and keep skills and reactions topped up during these waiting periods; but it must take place without having any form of signature outside the vehicle. So a simulator would be needed, and the best form of simulator would be a videotape. Once there is a videotape deck, it can fairly easily be	What forms and aspects of training could be implemented before and during confinement?		

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 015	persuaded to play educational, documentary and feature tapes. . . I would see audio cassettes as the source of software, including training programs, for the on-board computer; and the video unit (complete with its own soundtrack) being slaved to this computer for the play-back".			
	15.4 Physical Fitness - "This must be maintained both to avoid impairment of morale during the waiting period and to leave them in every way fit to fight at the end of it. Isometric exercise routines should in any event be taught to all soldiers and airmen as part of their evasion and escape training, so that they can lie up and remain able to move instantly, far and fast".	What types of exercises, isometric and otherwise, could be implemented before and during confinement?		
	15.5 Chemo-therapeutic Support - ". . . there is a good case for the use of amphetamines to extend endurance both in commando-type raids and in intensive phases of normal operations. The problem comes when the bought time has to be paid for. If the climax of the raid has to be postponed 24 or 48 hours at the last moment, or the clinching thrust of an operation goes awry, the commander is left with troops far less capable than they would otherwise have been".	Is there a role or place for the use of chemical therapeutic agents (e.g., amphetamines for extended operations; barbituates for facilitating needed sleep/rest cycles)?		

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 015	15.6 Water - "The primary need for comfort and well-being under confined and most other conditions is an ample supply of water. The vehicle's under-armor supplies of water and fuel must be conserved during the waiting period".			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 016

SECURITY CLASSIFICATION: Unclassified

TITLE: The effects of confinement on intellectual and perceptual functioning.

AUTHOR(S): D. W. Ormiston and B. Finkelstein

ORGANIZATION (AGENCY): Aerospace Medical Lab., Aeronautical Systems Div., Air Force Systems Command (ASD Technical Report 61-577).

LOCATION: Wright-Patterson Air Force Base

DATE: 1961

SUBJECT: Twenty Air Force officers were split into two groups -- confined and unconfined -- and then further subdivided into test diet and control diet groups. Test tasks consisted of arithmetic memory of digits, confusion sentences, nonsense syllables, verbal analogies, same-opposite word meanings, logical reasoning, embedded figures, form discrimination, aerial reconnaissance, and dual compensatory tracking. When not working on these tasks, subjects monitored warning lights. Confined subjects stayed in the capsule 48 hours; unconfined only while working. All groups had normal sleep cycles. Test diet was a low residue diet.

NATURE OF RESEARCH:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN _X_	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT _X_	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO _X_	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 016	16.1 Close confinement for 48 hours has no effect on intellectual functioning as measured by items similar to those of standard intelligence tests. 16.2 Subjects maintain their perceptual speed and accuracy, and form discrimination under confinement conditions. 16.3 Confinement did not degrade warning light monitoring. 16.4 Confined subjects exhibit irritability, sometimes fear and panic, but not the bizarre behavior patterns of sensorily deprived subjects. 16.5 The test diet was rated less acceptable than the control diet.	Confinement in and of itself did not appear to have an adverse effect on standard measures of intellectual and perceptual functioning.	3	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 017

SECURITY CLASSIFICATION: Unclassified

TITLE: Human factor problems in anti-submarine warfare. Human performance during five days confinement.

AUTHOR(S): J. J. McGrath, C. H. Maag, J. F. Hatcher, and W. P. Breyer

ORGANIZATION (AGENCY): Human Factors Research, Inc. (Technical Memorandum 206-14.)

LOCATION: Los Angeles, CA

DATE: 1962

SUBJECT: The study describes how two men performed during 120 hours of continuous confinement in a low-pressure, pure-oxygen environment (six foot cube cabin). The subjects worked alternately for five-hour periods and were evaluated on five performance tests: vigilance task, memory span test, attention test, time perception task, and object identification task.

NATURE OF RESEARCH: CLE ___ CFE _X_ FOM ___
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION: OP _X_ MA ___ SU ___

MAJOR RISK AREA: EN _X_ IP ___ MA ___ CO ___ OH ___

TYPE OF DATA: QT ___ QL _X_ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO _X_ HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 017	17.1 Detection performance deteriorated as long as subjects remained in an essentially unchanging environment. 17.2 Confinement did not affect memory span, although performance on the attention test seemed to deteriorate during the session. One subject showed decrements on the time-perception and object-identification tests, but the other did not.	Human performance tasks requiring vigilance and attention degrades under conditions of confinement.	2	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 018

SECURITY CLASSIFICATION: Unclassified

TITLE: Human group performance during confinement.

AUTHOR(S): E. A. Alluisi, T. J. Hall, G. R. Hawkes, and W. D. Chiles

ORGANIZATION (AGENCY): Lockheed-Georgia Company; Human Factors Research Dept. (Final Report ER 6024.)

LOCATION: Marietta, GA

DATE: 1962

SUBJECT: This study deals with crews of men who were confined for prolonged periods (15 to 30 days) in a 1100 cubic foot environment that demanded considerable activity. The study compared a work-rest schedule of four hours on duty and two hours off duty to a schedule of four hours on and four hours off duty. While on duty, the operators were tested on a battery of six performance tasks, including auditory vigilance, warning-light monitoring, probability monitoring, arithmetic computation, code-lock solving, and target identification.

NATURE OF RESEARCH:	CLE X	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN X	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT ___	QL X	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 018	18.1 A relative minimum of selection suffices to identify highly motivated subjects who maintained acceptable performance levels on a 4 - 2 work/rest schedule for at least two weeks. 18.2 Crew members maintained their performance on a 4 - 4 schedule better.	18.3 When personnel must stay highly alert around the clock for moderately long intervals, the 4 - 4 schedule is recommended.	1	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 019

SECURITY CLASSIFICATION: Unclassified

TITLE: Behavioral testing during a 7-day confinement: The information processing task.

AUTHOR(S): R. M. Patton

ORGANIZATION (AGENCY): Ames Research Center (NASA Technical Note D-1973).

LOCATION: Moffett Field

DATE: 1963

SUBJECT: This study investigated how well two subjects, confined for seven days in 123 cubic feet of useable volume in a mocked up space capsule performed on an information processing task (locating and marking certain designated letters among an array of letters). Over the course of confinement, both subjects showed faster speed scores, but one subject made less errors, while the other subject showed no significant change.

NATURE OF RESEARCH: CLE _X_ CFE ___ FOM ___
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION: OP _X_ MA ___ SU ___

MAJOR RISK AREA: EN _X_ IP ___ MA ___ CO ___ OH ___

TYPE OF DATA: QT ___ QL _X_ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO _X_ HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 019	19.1 Over the course of confinement, both subjects showed faster speed scores, but one subject made less errors, while the other subject showed no significant change. 19.2 Task complexity had a marked effect on speed and error scores; however, task performance was maintained at a reasonably high level throughout the seven-day confinement.	Under conditions of this study, subjects maintain proficiency on an information processing task in a small capsule.	1	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 020

SECURITY CLASSIFICATION: Unclassified

TITLE: Combined arms in a nuclear/chemical environment - summary evaluation report phase I

AUTHOR(S): LTC Edward S. Draper and LTC John J. Lombardi

ORGANIZATION (AGENCY): U.S. Army Chemical School

LOCATION: Fort McClellan, AL 36205-5020

DATE: March 1986

SUBJECT: Evaluation of the ability of a combined arms force (mechanized infantry platoon) to operate for sustained periods on the integrated battlefield under nuclear/chemical conditions.

NATURE OF RESEARCH: CLE ___ CFE _X_ FOM ___
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION: OP _X_ MA ___ SU ___

MAJOR RISK AREA: EN ___ IP ___ MA ___ CO _X_ OH ___

TYPE OF DATA: QT _X_ QL _X_ SJ _X_

AFV RELEVANCE: NO ___ SL ___ MO ___ HI _X_

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 020	20.1 Direct Fire engagements by all weapons decreased by 52% in nuclear chemical environment (NCE).	Difficulty in using direct fire weapons over a 72-hour period (in which platoons required to operate continuously for 12 hours in MOPP 4 or be completely encapsulated) degrades performance.	1	1
	20.2 M16 engagements decreased by 59% under NCE.	Same.	1	1
	20.3 Engagement efficiency (sum of hits divided by total shots fired).	Soldiers have difficulty laying their weapons or engage false targets or both under NCE.		
	20.4 Battle intensity, measured by shots fired per minute, in the attack decreased by 69% under NCE.	According to Air Land Battle & Army 21 concepts, and FM 100-5, Operations future battlefield intensity is supposed to increase rather than decrease.		
	20.5 M60 machine gun engagement range increased by 62% under NCE.	Destruction of threat targets is less accurate at longer ranges.	1	2
	20.6 Fratricidal engagements increased 360% under NCE.	Disorientation, frustration, confusion, and irritability were reasons given by crew members for fratricidal engagements.	1	2
	20.7 Ammunition expenditures as measured by trigger pulls decreased by 43% in the attack and by 22% in the defense under NCE.	This is a second measure suggesting that future battlefield intensity, at least in certain task areas, may decrease rather than increase.	1	1
	20.8 Percentage of threat targets engaged at least once in the attack decreased 25% under NCE.	Soldiers appear to see less and shoot less under NCE.	1	1

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 020	20.9 Percentage of threat targets destroyed during attack decreased 22% and by 25% during night defense under NCE. For day defense, an 11% increase was realized. M16 skills decreased 40%; indirect fire skills increased 100% under NCE.	Target detection and accuracy of direct fire weapons are problems under NCE. Personnel wearing M17A1 masks tend to cant their heads when firing M16. Increased use of indirect fire is likely related to performance difficulties with M16.	1	2
	20.10 Time to complete attacks increased 82% under NCE.	Greater battle durations are attributed to command and control problems, movement difficulty, and general fatigue.	1	2
	20.11 Friendly losses for infantry in the attack increased 32% under NCE; APC losses increased 130%	Friendly losses attributed to generalized fatigue and dehydration occurring under NCE conditions.	1	1
	20.12 Loss Exchange Ratio (ratio of killed attacker to killed defender per segment) increased 66% under NCE.	Doctrine stipulates a 3:1 attack/defender ratio should be maintained for a successful attack under NCE; these ratios were not maintained.	1	1
	20.13 Percentage of platoon leaders killed in attack increased 34% under NCE, but decreased under NCE by 54% in the defense. Highest percentage of platoon l aders killed under NCE attack (80%) and NCE defense (40%) occurred during 12 hours of continuous MOPP 4.	Continuous MOPP 4 operations leads to high platoon leader casualties, jeopardizing command and control.	1	1
	20.14 Time to replace killed comm ders increased 343% under NCE.	Degradation of command and control attributed to fatigue, changes in mental attitudes on part of leaders, and decrease in overall soldier awareness of environment.	1	1

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 020	20.15 Platoon leaders assessed as casualties were replaced 35% less under NCE.	Same.	1	1
	20.16 Number of reported communications equipment outages increased 27% under NCE.		1	--
	20.17 Radio message frequency increased by 47% under NCE and duration increased by 53%.	Radio messages reported as difficult to understand and garbled in MOPP 3 and MOPP 4. Increased transmission time in NCE increases vulnerability to enemy EW and indicates need for a better communications capability for our protective masks.		
	20.18 Frequency of calls for indirect fire during attacks increased under NCE by 209%	Increase is attributed to longer duration of NCE attacks and soldiers' lack of confidence in their ability to use direct fire weapons.	1	2
	20.19 Time spent in camouflage actions decreased by 31% in NCE and number of camouflage actions decreased by 39% in NCE. No camouflage actions were undertaken after 46th hour of NCE operation.	Extended operations in protective gear compromised sound tactical camouflage practices, especially by the third day.	1	2
	20.20 Average time to conduct a complete decontamination (personnel, vehicles, equipment) of the mechanized infantry platoon was 83 minutes.	Doctrinal shift of responsibility for personnel decontamination from chemical decontamination units to the contaminated unit was considered validated. Two hours of training were considered adequate for the validation.	1	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: EN 021

SECURITY CLASSIFICATION: Unclassified

TITLE: The effects of the chemical defense ensemble and extended operations on performance and endurance of combat vehicle crews.

AUTHOR(S): Don Headley

ORGANIZATION (AGENCY): U.S. Army Research Institute

LOCATION: Alexandria, VA

DATE: 1987

SUBJECT: Research investigated the effects of wearing MOPP gear on crew performance during extended operations. What crew tasks become degraded? Is decline sudden or gradual? What happens to accuracy and completeness with extended operations? Tank, howitzer and infantry fighting vehicle crews were studied.

NATURE OF RESEARCH:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN _X_	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT _X_	QL _X_	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI _X_	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 021	21.1 Tank crews in MOPP 4 trials lasted from 3.3 to 15 hours. Of 73 crewman starts, 32 crewman (44 percent) ended as medical casualties; 17 of the 19 tank starts ended as combat ineffective tanks due to reduced crew size.	Relatively hot temperatures played a significant role in the shortened durations for howitzer crews in full MOPP, as did the hot and humid conditions for the "dual-encapsulated" armor crews. Infantry crews, by virtue of food-rest-sleep breaks and MOPP gear changes, lasted some 60 hours under milder weather conditions. These results underscore the importance of other factors which interact with confinement and have a significant influence on crew performance during extended operations.	1	1
	21.2 Leadership apparently played a role in endurance as well as regimen. Platoon leader tanks remained in MOPP 4 iterations longer than the other tanks -- an average of 10.8 versus 6.4 hours -- and were the last in the platoon to become ineffective.	Items of concern regarding the MOPP ensemble include: bulkiness and chaffing of rubber gloves; soggy mask filters (from humidity) causing breathing difficulties; and the need for optical inserts for eyeglass wearers. Maintaining suit integrity is critical; any feature of the ensemble which causes discomfort is likely to lead to MOPP regimen violations.		
	21.3 Howitzer crews in MOPP 4 trials lasted 3.8, 1.9, and 2.1 hours compared to the MOPP 0 condition which lasted 19.4 hours. Trials were terminated primarily for medical casualty reasons.	Cooling vests and ventilated facepieces alleviate some discomfort; overpressurized cabins allow crews to operate in MOPP 2 status during lengthy engagements and periods of inactivity.		
	21.4 For howitzer crews, the average time to fire the first rounds of a mission are 5.5 times higher under MOPP 4 than under MOPP 0.	A speed/accuracy trade-off was suggested by some of the performance data; the howitzer and BIFV crews were able to maintain accuracy on the tasks examined, but sometimes at the expense of increased time.		

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
EN 021	21.5 For howitzer crews, the average interround interval averages for the MOPP 4 crew were 42 and 47 seconds (large and small missions respectively) 26 and 20 seconds for MOPP 0.	Observational evidence suggests that MOPP 4 soldiers tend to take shortcuts in the absence of proper leadership; lack of adherence to tanker regimen was visible among nonplatoon-leader tanks.		
	21.6 In terms of Bradley Infantry Fighting Vehicle (BIFV) crews, MOPP 4 crews were able to endure equally in length to their MOPP 1 control runs (approximately 60 hours) under the conditions of a 45-minute rest break and MOPP change at the end of each 6-hour cycle, 5-hour sleep period after every three cycles, and three meals per day.	Training is an absolute necessity for not just habituation to MOPP 4 regimen, but for effectively performing combat missions. Simply placing troops in full MOPP posture (independent of the compounding problems that high temperatures cause) represents a decrement because of communication, command and control, sensory motor, and morale problems. For timely execution of combat missions, staying in as low a MOPP level as possible is desirable.		
	21.7 In the endurance test for BIFV crews, MOPP 4 crews became combat ineffective 31 to 38 hours under the constraints of no rest breaks, MOPP change or food (a sleep break was allowed).	Note: Weather conditions for both phases were relatively mild; frequent exposure to outside air (as opposed to long buttoned-up periods) was a prominent feature of the BIFV tests.		

INFORMATION PROCESSING (IP)

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 001

SECURITY CLASSIFICATION: Unclassified

TITLE: Risk, effort and fatigue. In M.G. Wade & R. Martens (Eds.) Psychology of motor behavior and sport. Urbana, Ill: Human Kinetics.

AUTHOR(S): D.H. Holding

ORGANIZATION (AGENCY):

LOCATION:

DATE: 1974

SUBJECT: Subjects, using the COPE (Choice of Probability and Effort) test, were given a choice of the effort they may apply to the solution of a problem, with the probability of success corresponding to the effort exerted.

NATURE OF RESEARCH:	CLE X	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE.	NO ___	SL ___	MO X	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 001	1.1 After 24-32 hours on a multiple performance battery, subjects were found to choose the low effort/low probability of success strategy.	A prolonged period of cognitive overload may put an individual into a state where any further effort to meet task demands is aversive and thus avoided.	2	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 002

SECURITY CLASSIFICATION: Unclassified

TITLE: Sleep deprivation and performance. In W.B Webb (Ed.) Biological rhythms, sleep and performance. New York: John Wiley and Sons, Ltd.

AUTHOR(S): L.C. Johnson

ORGANIZATION (AGENCY)

LOCATION.

DATE: 1982

SUBJECT: Those aspects of primarily cognitive tasks which show differential sensitivity to sleep loss were summarized.

NATURE OF RESEARCH.	CLE X	CFE X	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL X	SJ ___		
AFV RELEVANCE.	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 002	1.1 Duration of the task. Tasks which have long duration times (e.g., monitoring radar) are especially affected by sleep loss (Donnell, 1969; Wilkinson, 1961, 1965).	Consider ways in which duration of task can be shortened or ways to respond differently to the same stimulus.	2	1
	1.2 Task difficulty. The more cognitively demanding the task, the greater its sensitivity to sleep loss (e.g., *increasing the rate required* of subjects in solving mental arithmetic problems causes performance decrements under sleep deprived conditions, Williams & Lubin, 1967).	Cognitively demanding tasks should be kept to a minimum. Consider use of decision aids when necessary.	2	1
	1.3 Feedback. Tasks for which feedback is given are more resistant to the effects of sleep loss.	Consider visual or auditory feedback for confirmation of successful task completion.	2	2
	1.4 Practice. Tasks which are well learned and repeatedly practiced are more resistant to the effects of sleep loss.	Allow for periods of overlearning in formal training cycles and also training that occurs "in the cracks".		
	1.5 Complexity - Tasks which require a sequence of operations or division of attention are especially sensitive to sleep loss.	Simplify complex tasks.		

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 002	1.6 Learning and Memory - Tasks which depend on short term memory are very sensitive to sleep loss (Williams, Geiseking & Lubin, 1966; Williams & Williams, 1966). 1.7 Work/rest schedules - Performance on several tasks (i.e., reaction time, logical reasoning, and encoding/decoding) decline quickly when subjects are required to work continuously during the sleep deprivation period (Angus & Heslegrave, 1985). Rest periods (without sleep) between performance tests help to maintain performance during sleep deprivation. 1.8 High interest levels - High interest level in the task will partially offset the deleterious effects of sleep loss (Wilkinson, 1964).	Avoid performance of tasks which require new learning during continuous or sustained operations.		

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 003

SECURITY CLASSIFICATION: Unclassified

TITLE: Sleep loss and continuous cognitive work. Reprint from the 24th Proceedings of the Defense Research Group. Seminar: The human as limiting element in military systems.

AUTHOR(S): Ronald J. Heslegrave and Robert G. Angus

ORGANIZATION (AGENCY): NATO Defense Research Section, (Report DS/A/DR(83) 170)

LOCATION: Toronto, Canada

DATE: 1985

SUBJECT: The study investigated the effects of sleep loss and sustained mental work on cognitive performance with an emphasis on cognitive abilities required in a command and control environment. Results from previous studies may not generalize well to the sustained, high-intensity, command post operations and estimates of performance degradation from these studies may be underestimates. Therefore, present study focused on continuous cognitive work.

NATURE OF RESEARCH: CLE _X_ CFE ___ FOM ___
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION: OP _X_ MA ___ SU ___

MAJOR RISK AREA: EN ___ IP _X_ MA ___ CO ___ OH ___

TYPE OF DATA: QT _X_ QL _X_ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO _X_ HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 003	3.1 Results showed that subjects had marked difficulty maintaining efficient performance patterns on the cognitive tasks over the 54 hour sleep deprivation period. Performance on all tasks deteriorated with substantial decrements occurring about 18 hours after the experiment began: 24 hours later another dramatic drop in performance occurred. 3.2 Degree of performance degradation was greater in magnitude than in previous studies using similar tasks. For example: 3.2.1 Serial reaction time task - previous studies showed correct responses remained at 90% of baseline following a night without sleep and 79% of baseline after the second night of sleep loss. In present study, correct responses dropped to 76% of baseline after first night and 43% of baseline during the second night. 3.2.2 Encoding/decoding task - Previous studies found no change in performance until the second night when performance was 50% of baseline. Present study revealed declines to 72% and 41% of baseline following the first and second nights of sleep deprivation.	Results demonstrated that 54 hours of sustained mental activity produced greater performance and mood degradation than had previously been observed over similar time periods and using similar dependent measures.	1	2

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 003	3.2.3 Logical reasoning task - Previous studies showed performance drops to 71% and 35% of baseline following 24 and 48 hours of sleep loss while present study showed drops to 57% and 26% during the same period. 3.3 Performance and mood in the present experiment showed minimal recovery as a consequence of the circadian rhythm approaching its normal acrophase during the second and third days.			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 004

SECURITY CLASSIFICATION: Unclassified

TITLE: Physical exercise and mental performance. Ergonomics, 16, 595-599.

AUTHOR(S): C. P. Davey

ORGANIZATION (AGENCY):

LOCATION:

DATE: 1973

SUBJECT: To investigate the effects of physical fatigue on short-term memory, Davey (1973) manipulated energy expenditure between 3,000 ft. lb. of work in 15 sec. and 50,000 ft. lb. of work in 10 min. The Brown-Poulton test of identifying a sequence of odd-even-odd digits from a continuous series presented at a rate of one per sec. was used in the present study.

NATURE OF RESEARCH: CLE X CFE ___ FOM ___
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION: OP X MA ___ SU ___

MAJOR RISK AREA: EN ___ IP X MA ___ CO ___ OH ___

TYPE OF DATA: QT X QL X SJ ___

AFV RELEVANCE: NO ___ SL ___ MO X HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 004	4.1 A moderate amount of exercise significantly improved mental performance and a very severe amount of physical exertion produced a deterioration. 4.2 An intermediate amount of physical exertion led to different results in different subjects. 4.3 The point at which facilitation gave way to impairment came with the varisd performance associated with pedalling the bicycle ergometer for 5 min. to perform 30,000 ft. lb. of work.	Such results suggest an inverted U relationship between physical exertion and subsequent mental performance.	3	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 005

SECURITY CLASSIFICATION: Unclassified

TITLE: Prelude to 2001: Explorations in human communication. American Psychologist, 26, 949-961.

AUTHOR(S): A. Chapanis

ORGANIZATION (AGENCY):

LOCATION:

DATE: 1971

SUBJECT: Chapanis studied the time required by teams of subjects to solve complex problems using modes of communication ranging from face to face communication to typewritten messages.

NATURE OF RESEARCH: CLE _X_ CFE ___ FOM ___
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION: OP _X_ MA ___ SU ___

MAJOR RISK AREA: EN ___ IP _X_ MA ___ CO ___ OH ___

TYPE OF DATA: QT _X_ QL ___ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO _X_ HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 005	5.1 In the typewriting mode, subjects took, on the average, two and one-half times as long to solve problems as in the communication rich mode. 5.2 Face to face communications resulted in the least time to solve problems and were characterized by an enormous number of interchanges.	Within vehicle communication procedures should allow for maximum use of face-to-face (unmasked) communication mode among crew.	2	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 006

SECURITY CLASSIFICATION: Unclassified

TITLE: Speech communication. In H. P. Van Cott and R. G. Kinkade (Eds.), Human engineering guide to equipment design. Washington, D.C.: U.S. Government Printing Office.

AUTHOR(S): K. D. Kryter

ORGANIZATION (AGENCY):

LOCATION:

DATE: 1972

SUBJECT: The effects of noise on speaker-recipient communication was investigated.

NATURE OF RESEARCH:	CLE X	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 006	While there is some discrepancy in some areas on the effects of noise, the effects of noise on speech communication are quite dramatic. 6.1 In the range of 600 to 4800 Hz., a 70 db noise reduces comprehension between a speaker and listener communicating at a distance of one meter; a 25 db noise will cause interference at 100 feet. 6.2 Morgan, Cook, Chapanis & Lund (1963) report figures showing speech interference levels as a function of distance between speaker and listener (as above) and voice volume of speaker (normal voice, raised voice, very loud voice, and shouting).	Noise dampening design efforts for reducing within-vehicle ambient noise levels should find the speech interference tables useful.		

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 007

SECURITY CLASSIFICATION: Unclassified

TITLE: Effective training for target identification under degraded conditions.

AUTHOR(S): John Cockrell

ORGANIZATION (AGENCY): U.S. Army Research Institute (Technical Paper 358)

LOCATION: Alexandria, VA

DATE: April, 1979

SUBJECT: 96 subjects placed in one of 4 groups differing in the amount of degradation of targets were asked to identify various test targets.

NATURE OF RESEARCH:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP _X_	MA ___	CO ___	OH ___
TYPE OF DATA:	QT _X_	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI _X_	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 007	7.1 Subjects trained on targets degraded to 33% visibility identified 60% of 33% degraded test targets whereas subjects trained on targets of 0% degradation identified 12% of test targets degraded to 33% visibility.	In continuous operations visibility maybe poor due to low light levels and poor judgement. Most targets seen will be degraded. Soldiers find the most salient feature to code, but when this feature is degraded they can not make the identification. Training identification programs should continue to include degraded targets.	1	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 008

SECURITY CLASSIFICATION: Unclassified

TITLE: Long range target recognition and identification of camouflaged armored vehicles.

AUTHOR(S): William Warnick, Garvin Chastain, and William Ton

ORGANIZATION (AGENCY): U.S. Army Research Institute (Technical Report 79-A13)

LOCATION: Alexandria, VA

DATE: May, 1979

SUBJECT: In the first of two experiments, 12 trained officer observers were split into two groups, and asked to identify five vehicles from 5 views at scaled ranges of either 3000 or 4000 meters using a XM65 weapons sight. Observers were first given a pretest, then given training with feedback, and finally given a post-test. The second experiment was designed to determine if observers could identify camouflaged vehicles hidden in terrain using a similar design as experiment 1.

NATURE OF RESEARCH:	CLE ___	CFE X	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP ___	MA ___	SU X		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL X	MO ___	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 008	8.1 There were no differences between 3000 and 4000 meter uncamouflaged target identification. Pretraining identification scores averaged 62% but rose to 96% during the 25 minutes of training. Post-test scores averaged 98%.	The continued training of target identification is vital to accurate performance. This will be increasingly important during CONOPS as cognitive function deteriorates.	1	1
	8.2 The front view of vehicles degrades performance more than any other view.	Training should emphasize front view differences of vehicles to aid in identification.	1	2
	8.3 There were no differences in identifying camouflaged targets at ranges of 2500 and 3500 meters. 46% of targets were correctly identified at the pretraining phase. This rose to 79% for training and 90% for the posttest.	Programs aimed at the training of camoflaged and hidden target identification should continue.	1	2
	8.4 The addition of camouflage patterns increased the number of trials required to train observers.	The perceptual difficulties which arise from attempting to identify camouflaged vehicles necessitates the need for increased training time.	2	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 009

SECURITY CLASSIFICATION: Unclassified

TITLE: Binocular scanning performance of soldiers wearing chemical biological protective masks. In R. Swezey, T. Post, L. Strother, and M. Knowles (Eds.), Proceedings of the Human Factors Society 19th Annual Meeting. Santa Monica, CA: Human Factors Society

AUTHOR(S): David Harrah

ORGANIZATION (AGENCY):

LOCATION:

DATE: October, 1985

SUBJECT: 38 soldiers participated in one of two studies designed to measure the increase in the amount of time required to visually scan an area 24 feet wide by 8 feet high from a distance of 20 feet which occurred when wearing various designs of protective masks and using the M19 binoculars.

NATURE OF RESEARCH:	CLE _X_	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP _X_	MA ___	CO ___	OH ___
TYPE OF DATA:	QT _X_	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI _X_	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 009	9.1 The field of view decreased from 6.2° and 6.6° for the two studies with no mask using binoculars to 3.5° and 2.8° using the M17 mask and binoculars.	The M17 protective mask effectively reduces the field of view between 44% and 58% from using no mask.	1	1
	9.2 The mean scanning time for the M17 mask increased to 38 and 44 seconds for the two studies from 26 seconds with no mask. This represented an increase of 41% and 69%.	The reduced field of view appears to cause an increase in visual scanning time. Efforts to increase the field of view of protective masks as much as possible should continue. Payoffs should include reduction in visual scanning time.	1	1
	9.3 Scanning rates increased from an average of 7.4 degrees/sec. for the no mask condition to 10 degrees/sec. for the worst mask condition.	Soldiers compensate for the reduced field of view of protective masks by increasing to some degree their scan rates. This increase may lead to fewer and less accurate detection of targets. Trade-offs between field of view of protective masks and time to detect targets should be determined.	1	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER. IP 010

SECURITY CLASSIFICATION: Unclassified

TITLE: Different difficulty manipulations interact differently with task emphasis: Evidence for multiple resources. Journal of Experimental Psychology, 8, 146-157.

AUTHOR(S): Daniel Gopher, Michael Brickner, and David Navon

ORGANIZATION (AGENCY):

LOCATION:

DATE: 1982

SUBJECT: Six subjects performed a dual axis pursuit tracking task or a novel typing task both alone and together in order to determine subjects' ability to timeshare two tasks. Both difficulty of task and task priorities were varied.

NATURE OF RESEARCH:	CLE X	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL X	MO ___	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 010	10.1 Performance operating characteristic (POC) curves indicated that these two tasks compete for common resources with performance being attenuated when the two tasks were performed together. However, the typing task also contained a cognitive component which the tracking task did not.	Tasks which compete for common resources will produce poorer performance than tasks which compete for different resources. Tasks which do not compete for the same resources will produce better performance for each task than if they competed for resources.	2	2
	10.2 Increasing task difficulty produced decrements in performance over and above the effects of task sharing. In single task performance, poor performance was associated with increasing cognitive load as opposed to increasing motor load, whereas during task sharing, poor performance was associated with increased motor difficulty rather than cognitive load.	Two resources which appear not to compete with each other are motor resources and cognitive resources. When soldiers must perform two tasks together and they are difficult, the tasks should not compete for motor or response resources or performance can be expected to degrade on both of the tasks. Task difficulty can be expected to affect performance on another task only to the degree that they share common resources.	2	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 011

SECURITY CLASSIFICATION: Unclassified

TITLE: The effect of workload on performance of operators monitoring unattended ground sensors.

AUTHOR(S): Lawrence Edwards, Sterling Pilette, Billy Biggs, and Harold Martinek

ORGANIZATION (AGENCY): U.S. Army Research Institute (Technical Paper 321)

LOCATION: Alexandria, VA.

DATE: September, 1978

SUBJECT: 28 enlisted trained unattended ground sensor (UGS) operators monitored displays which varied on the number of sensors displayed (27, 54 or 108) and the amount of activity produced by the sensors (low 2 or 3 targets per 27 sensors per 30 min. high - 6 to 8 targets per 27 sensors per 30 min).

NATURE OF RESEARCH:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION	OP ___	MA ___	SU _X_		
MAJOR RISK AREA:	CH ___	IP _X_	MA ___	CO ___	OH ___
TYPE OF DATA:	QT _X_	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI _X_	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 011	11.1 As workload increased from 27 to 54 to 108 sensors, the percent of targets detected degraded from 71% to 57%	Increasing the number of sensors places a burden on the soldier and decreases performance. Possible solutions include using fewers sensors and having monitors summarize large numbers of sensors.	1	1
	11.2 As activity level increased from low to high the percentage of targets detected decreased from 74% to 40%.	Increasing the activity level results in a decrease in the percentage of targets detected. Solutions include having monitors summarize areas where large numbers of sensors turn on.	1	1
	11.3 Regardless of workload, operators underestimate the true speed of targets.	This may be due to the false assumption that targets are traveling in a straight line.	2	2
	11.4 As activity level increased average direction deviation also increased with $\pm$ 34.4° for the low activity and $\pm$ 46.4° for the high activity.	Operators may have difficulty in distinguishing sensor activations caused by one target from activations caused by another target. More training and experience may reduce this problem.	2	1
	11.5 Only 29 false alarms for the 28 operators occurred; too few to be statistically analyzed.	Errors of omission occur more frequently than errors of commission. In CONOPS errors of omission increase and thus methods must be developed to decrease this. Training for high workload conditions, summarizing target displays and increasing motivation with feedback may be useful.		

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 012

SECURITY CLASSIFICATION. Unclassified

TITLE: Effects of chemical protective handwear and headwear on manual dexterity. Proceedings of the Human Factors Society 30th Annual Meeting. Santa Monica, CA: Human Factors Society.

AUTHOR(S): Richard F Johnson and Lynn A. Sleeper

ORGANIZATION (AGENCY):

LOCATION:

DATE: October, 1986

SUBJECT: 22 soldiers performed a one handed and two handed test of manual dexterity while 1) bare-handed and bare-headed, 2) bare-handed with M17A1 gas mask with hood, 3) bare-headed wearing butyl rubber gloves and 4) wearing both mask and hood.

NATURE OF RESEARCH:	CLE X	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 012	12.1 One handed and two handed dexterity is better bare-handed ($m = 85$ sec. for one handed and $m = 70$ sec. for two handed) than gloved ($m = 130$ sec. for one handed and $m = 200$ sec. for two handed).	Possible solutions to reducing the degradation of manual dexterity by gloves include designing switches, knobs and buttons to be used with gloves, allowing extra time for manual dexterity tasks and providing more training on tasks performed while wearing gloves.	2	1
	12.2 There was no effect on manual dexterity for soldiers wearing masks on one handed ($m = 85$) or two handed ($m = 70$) dexterity tasks.	Masks do not appear to interfere with manual dexterity.	2	1
	12.3 Performance leveled off after 4 days when subjects wore gloves and 3 days without gloves.	More training maybe useful to improve performance with gloves.	2	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 013

SECURITY CLASSIFICATION: Unclassified

TITLE: Effects of fatigue from wearing the AN/PVS-5 night vision goggles on skills involved in helicopter operations.

AUTHOR(S): Garvin Chastain and Albert Kubala

ORGANIZATION (AGENCY): U.S Army Research Institute (Research Report 1217)

LOCATION: Alexandria, VA.

DATE: July, 1979

SUBJECT: 10 army aviators performed a series of tests designed to relate to critical helicopter tasks and maneuvers both before and after a 45 minute to 1.5 hours of helicopter flight using night vision goggles. There are a number of confounds in this research.

NATURE OF RESEARCH:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP _X_	MA ___	CO ___	OH ___
TYPE OF DATA:	QT _X_	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL _X_	MO ___	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 013	13.1 There were no differences on rotary pursuit test of eye-hand coordination.	The brief 45 min. to 90 min. use of NVG was not sufficient to induce eye hand coordination performance decrements.	3	3
	13.2 Longer response times occurred in the post flight condition to a red light than to a green light or in preflight condition to a red light on a simple reaction time test.	It was thought this may be due to red light responses always performed with the right hand which became fatigued by helicopter flight.	3	2
	13.3 In a discrimination reaction time test, faster response times occurred to a red light than a white or green light. There was no difference before or after flights.		3	3
	13.4 There were no differences on a two hand coordination test for pre and post flight performance.	Soldiers can wear NVG for 45 min. to 90 min. with little expected decrement in performance.	3	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 014

SECURITY CLASSIFICATION: Unclassified

TITLE: Isolation and disorientation: In J.D. Hardy (Ed.), Physiological problems in space exploration. Charles C. Thomas Publisher

AUTHOR(S): Rendall M. Chambers

ORGANIZATION (AGENCY):

LOCATION:

DATE: 1964

SUBJECT: Chapter reviews and summarizes research on isolation and disorientation as it relates to problems encountered by man during space travel.

NATURE OF RESEARCH:	CLE X	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN X	IP ___	MA ___	CO ___	OH ___
TYPE OF DATA:	QT ___	QL X	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 014	Space travel research has identified several adverse effects of prolonged confinement with respect to skill performance proficiency:			
	14.1 Lapses - Temporary decrements or irregularities in performance, sometimes called microsleeps, which increase as time progresses.	Consider counter-measures such as mini-exercises and rest cycles to increase arousal levels of confined personnel.	2	2
	14.2 Approximation - Although task does not increase in difficulty, subject's behavior becomes less precise and is minimally compliant to task demands.	Consider requiring steps for completing a task to be invariant and kept to a minimum. Elimination of all unnecessary steps will be useful.	2	2
	14.3 Stereotyping - Regardless of the stimulus conditions, subjects tend to make the same response to all stimuli.	All stimuli, controls, and displays requiring different responses could be conspicuously different to avoid equivalent responding.	2	2
	14.4 Filtering - Subject systematically responds to some stimuli, but not others in performing task.	Consider mini-exercises or rest cycles as countermeasures.	2	2
	14.5 Queuing - Subject delays making certain responses which should be made during peak loads, but makes them later when workload is reduced.	Consider automation of some of the tasks and functions that occur during periods of peak load.	2	2
	14.6 Response Omission - Subject omits, reduces, or ceases to perform portions of the total task.	Consider mini-exercises or rest cycles as countermeasures.	2	2
	14.7 Other Response Tendancies - Increased lantency of response, increased			

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 014	error amplitudes, and errors in retrieving and processing information also occur during periods of prolonged confinement. NOTE: Above findings are highly variable and very sensitive to changes in the test situation.			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 015

SECURITY CLASSIFICATION: Unclassified

TITLE: Verbal communication in tracked combat vehicles.

AUTHOR(S): Charles Shoemaker, Georges Garinther and Joel Kalb

ORGANIZATION (AGENCY): U.S. Army Human Engineering Laboratory (Technical Memorandum 19-80)

LOCATION: Aberdeen Proving Ground, MD.

DATE: September, 1980

SUBJECT: In the first of two separate studies, the amount of noise generated was determined for six track vehicles at various speeds with the top open. In the second study, three communication systems (DH-132, DH-132 with EAR earplugs, and DH-132 with EARCOM intercom system) were evaluated. Four subjects wore each of the communication systems and identified 1000 spoken works in a room with noise simulated at the level experienced in a track vehicle - 107db, 95db, 85db.

NATURE OF RESEARCH:	CLE X	CFE ___	FOM ___		
	SIN ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 015	15.1 Measurement of A-weighted sound pressure level (db (A)) of six track vehicles moving at various speeds with hatches open produced a useful reference table of vehicle noise. Some values are produced below:	Tables are useful for comparison and development of noise attenuating devices for new vehicles as well as determining communication equipment needs.	1	2
	15.2 The mean intelligibility scores of the three communication systems at 107db were: DH-132 - 69.9% correct, DH-132/EAR - 44.1% correct, DH-132/EARCOM - 17.4% correct.	It was thought that the EAR earplug would attenuate noise but the operator could increase the volume of the intercom communications and this would increase overall intelligibility. This was not found to be the case. The DH-132 used alone was superior to the other two systems.	2	2
	15.3 The mean intelligibility scores for the three noise levels for the DH-132 were: 107db - 69.9% correct, 95db - 85% correct, and 85db - 90.3% correct.	Outside noise seriously degrades intelligibility of verbal communications using present technology. Consider reducing vehicle noise and developing communication systems which are more efficient. Standard hand signals and codes, as well as redundancy of information may increase communication accuracy.	2	1

Type of Vehicle	Speed (mph) 10	20
M1	94db	104db
M60A1	98db	100db
M107	110db	115db
M109A1*	107db	109db
M113A1	103db	107db

*Based on 5 and 15 mph.

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 016

SECURITY CLASSIFICATION: Unclassified

TITLE Forward arming and refueling point (FARP) operations in a chemical-biological (CB) environment

AUTHOR(S): Alan M. Poston

ORGANIZATION (AGENCY): U.S Army Human Engineering Laboratory, (Technical Memorandum 16-85)

LOCATION: Aberdeen Proving Ground, MD.

DATE: October, 1985

SUBJECT: Comparisons were made between 6 army personnel, broken into three teams of two, wearing either MOPP IV or no MOPP clothing on tasks involving rearming an AH-64 mock-up with HELLFIRE missiles and 2.75-inch rockets. The experimental scenario called for rearming one AH-64 every 30 minutes with 8 HELLFIRE missiles and 38 2.75-inch rockets. The effects of temperature on rearming time were also examined.

NATURE OF RESEARCH:	CLE ___	CFE X	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP ___	MA ___	SU X		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 016	16. 1 It took the three teams an average of 23 minutes 19 sec. per aircraft in MOPP IV to complete the rearming compared to an average of 19 min. and 53 sec. to complete the rearming in MOPP 0.	MOPP IV increased in the present study the amount of time required to complete the physically demanding task of rearming by 17%.	2	1
	16. 2 Team 1 withdrew from exhaustion after loading their second aircraft. Team 2 was terminated during the loading of their second aircraft due to extreme heart rates, and Team 3 was terminated during the loading of their third aircraft due to extreme core temperatures.	The extreme physical activity required during rearming and the use of current MOPP IV gear drastically reduce the endurance of soldiers. Consider mechanizing physically demanding tasks and using micro-cooled suits.	2	1
	16. 3 As temperature increased from 77°F WBGT to 85°F WBGT, soldiers took longer to complete the rearming tasks.	The use of micro-cooled suits may improve performance on some physical tasks during high temperatures.	2	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 017

SECURITY CLASSIFICATION: Unclassified

TITLE: Speech intelligibility evaluation of the XM-29 chemical biological protective mask and hood.

AUTHOR(S): Richard S. Bruno

ORGANIZATION (AGENCY): U.S. Army Human Engineering Laboratory, (Technical Memorandum 10-79)

LOCATION: Aberdeen Proving Ground, MD.

DATE: June, 1979

SUBJECT: A variety of MOPP masks and hoods were evaluated for speech intelligibility by having six soldiers, wearing various configuration of masks and hoods, both say and listen to words presented from the Modified Rhyme Test in a laboratory situation.

NATURE OF RESEARCH.	CLE X	CFE ___	FOM ___
	SIM ___	MOD ___	EJ ___
MILITARY FUNCTION:	OP X	MA ___	SU ___
MAJOR RISK AREA:	EN ___	IP X	MA ___ CO ___ OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___
AFV RELEVANCE:	NO ___	SL ___	MO X HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 017	17.1 Results indicated that in face to face communications (7 feet away, non-electronically aided) talking to and listening with the M17A1 mask and the XM-29 mask both produced 92% intelligibility. Communications between the M-9A1 mask with M-3 SP hood and the M-9A1 mask with M-3 hood resulted in 69% intelligibility. Soldiers, each wearing the M17A1 mask with M-6A1 hood, had intelligibility scores of 90%.	Many of the systems evaluated in non-electronically aided face to face communications produce greater than 80% intelligibility.	2	2
	17.2 Evaluations of various masks and hoods with electronically aided communication devices indicated that all tested produced acceptable (by the authors standards 80% or above) accuracy. Some examples are communications between two soldiers each wearing the M-17A1 mask with M-6A1 hood and using the PASGT helmets and handsets produced 80% intelligibility, communications between soldiers each wearing the M-24A1 masks with M-7 hoods and using SPH-4 helmets resulted in 94% intelligibility.	Electronically aided communications devices with MOPP masks and hoods appear to produce 80% or better levels of intelligibility in laboratory conditions. These intelligibility scores are likely to be greatly attenuated in battle conditions when factors such as outside noise and fatigue begin to occur.	2	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 018

SECURITY CLASSIFICATION: Unclassified

TITLE HELAST II - A field study of the effects of mobility/agility on target presentation and defender reaction

AUTHOR(S): Andrew Eckles, Thomas Garry, William Mullen, and Herbert Aschenbrenner

ORGANIZATION (AGENCY): U.S. Army Human Engineering Laboratory, (Technical Memorandum 12-73)

LOCATION: Aberdeen Proving Ground, MD

DATE: July, 1973

SUBJECT: Three field tests were conducted to determine 1) how combat vehicles might appear to enemy gunners as targets, and 2) how increased mobility and agility of a target might affect engagements by enemy gunners. Crews in stationary M60 tanks were to detect and engage, with simulated fire, enemy vehicles of varying mobility/agility which traveled along a predetermined vegetated course at Ft. Knox. In the first test, a method for tracking realistically moving targets was developed. In the second test, film taken through the gunners sight allowed the determination of the degree to which a tank was visible to the enemy at various times. In the third test, the effects of mobility and agility of enemy vehicles on tracking were determined.

NATURE OF RESEARCH	CLE ___	CFE X	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 018	18.1 From study 1, tracking error (RMS) for azimuth was between .9 and 1.1 and for elevation was .8. This was larger than in several previous studies which claimed less than .5 RMS.	The increased tracking error was thought to be due to the realistic movement of the vehicles. Although attempts were made to keep a constant speed, the lateral and horizontal movements made in navigating the course gave the appearance of varying speed. This created tracking difficulties for the gunners. Training on realistic target movements may be useful in reducing tracking error.	2	2
	18.2 From study 2, movies were taken through defender gunsights of an M60 tank moving at 5 mph. Analysis of the film revealed that exposures of the enemy tank were brief, with 50% of all exposures involving a pathlength of less than 25 meters.	Because exposures of enemy tanks in this terrain were brief, training on tracking of brief target presentations may be useful.	1	1
	18.3 About 65% of the time the target was visible, the entire height of the vehicle (from cupola to bottom of hull) was visible. When the entire height was not visible, vegetation and not vertical terrain was masking the vehicle.	Reducing the height of the vehicle reduces the target visibility minimally. Slight changes in observer position were thought to result in large increases in target visibility. Methods should be developed to aid tank crews in determining the optimal position of their tanks.	1	2
	18.4 The number of detections, time to detect, and fire a first and second round and the accuracy of lay for each trigger pull were determined for an M60, M113, and X300. Overall, 71% of the targets were detected, 62% were identified, 55% were fired on at least once, and 38% fired on twice.	Figures indicate that improvements may be warranted in detecting and tracking targets. These improvements may come in the form of enhanced detection and tracking equipment as well as enhanced training.	1	1

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 018	18.5 By vehicle type, the M60 was fired on more times (63%) than either the M1 (50%) or the X300 (49%).	Vehicles which have increased mobility/agility tend to be more difficult to track and fire upon. Instrumentation, training or both may be used to alleviate this problem. In evading the enemy, the effective use of hiding in the terrain may be one way to increase survivability. Continued research should be performed in this area.	2	2

AFV DATA COLLECTION SHEET

<u>DOCUMENT IDENTIFICATION NUMBER</u>: IP 019

<u>SECURITY CLASSIFICATION</u>: Unclassified

<u>TITLE</u>: Performance, recovery, and man-machine effectiveness: Final report on a basic research program under Project THEMIS.

<u>AUTHOR(S)</u>: Clay George and Richard Dudek

<u>ORGANIZATION (AGENCY)</u>: U.S Army Human Engineering Laboratory, (Technical Memorandum 9-74)

<u>LOCATION</u>: Aberdeen Proving Ground, MD.

<u>DATE</u>: April, 1974

<u>SUBJECT</u>: This report summarizes the findings of a large number of studies funded under Project THEMIS to determine human performance and recovery under conditions of noise, vibration, unfavorable climatic conditions as well as the effects of motivation and nutrition on performance.

<u>NATURE OF RESEARCH</u>: CLE X CFE ___ FOM ___
SIM ___ MOD ___ EJ ___

<u>MILITARY FUNCTION</u>: OP X MA ___ SU ___

<u>MAJOR RISK AREA</u>: EN ___ IP X MA ___ CO ___ OH ___

<u>TYPE OF DATA</u>: QT X QL ___ SJ ___

<u>AFV RELEVANCE</u>: NO ___ SL ___ MO X HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 019	19.1 Vibration from 2 to 8 cps for 5 to 20 minutes caused an increase in reaction time 20 minutes after the vibration had ended from .43 seconds to .44 seconds. Travel time (start of movement to completion) increased from .27 seconds to .29 seconds during vibration. Vibration caused right handed subjects to stop short of alignment to a target on the right and to overshoot a target on the left.	Vibration can cause a .03 second increase in target acquisition (reaction time plus travel time) as well as reduce accuracy of acquisition. Tasks which require fast and accurate reaction times in a moving vehicle will be degraded. Consider not requiring extremely fast and accurate target acquisition times and developing devices to reduce the impact of this degradation.	3	3
	19.2 Short periods of vibration (5-8 cps) increased error rates on a target tracking task on a CRT display. However, as the amount of time under vibration increased, subjects made fewer and fewer errors. For long tracking tasks (4 hours) more errors were made under vibration than without vibration, and the number of errors increased more quickly over time than for non-vibration conditions.	Subjects do adapt to vibratory conditions. However, because of fatigue critical tracking tasks should not be performed in moving moving vehicles for over 2 hours.	3	3
	19.3 Temperature levels (dry bulb/wet bulb) of 80/67°F, 92/76°F and 102/86°F did not affect vigilance performance. However, more accurate performance occurred for short work periods (92% correct responses for up to 24 minutes) than for long work periods (78% correct responses for 50-74 minute work periods). Heat stress and time on watch interact to affect performance. Vigilance performance can be	Vigilance performance is not adversely affected for short periods (up to an hour) by high heat with the introduction of work/rest schedules. Long periods of vigilance in high heat stress will require more frequent rest periods.	3	2

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 019	maintained adequately in a high heat environment for up to an hour with a work/rest ratio of 2:1.			
	19.4 When a group was performing a close psychomotor task, performance with verbal communication at the beginning of the task followed by non-verbal communication was found to be superior to performance with no verbal communication at all.	Training for tasks in which verbal communication will be limited will be enhanced if standard non-verbal language is used. This enhancement may also occur if members of teams are trained together enabling soldiers to 'get used to' each others signals.	3	2
	19.5 On a task in which subjects, either singly or in pairs, used two dials to control a scriber to trace a maze, performance was faster (248.75 sec) for pairs than for individuals (328.42 sec).	Two men can coordinate their responses better than one man coordinating his own hands. Critical psychomotor tasks may be better performed by two men than one. However this must be used with caution because the loss of one man may make a task impossible.	3	3
	19.6 Subjects performed better (70% correct detections after 20 minutes) on a vigilance task if they had been isolated for 32 minutes prior to the task than subjects who had been isolated for only 2 minutes (50% correct detections after 20 minutes). Subjects eating a heavy meal (23% to 50% of their daily calorie allowance) prior to a vigilance task missed 30% more detections than subjects who ate a light meal.	Isolation is one method to enhance motivation levels which increase performance on vigilance tasks. Light snacks rather than heavy meals could be provided to soldiers just prior to performing vigilance tasks.	2	3

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 019	19.7 Four men were able to work at 30% and 50% of their aerobic capacity with no ill effects on oxygen uptake or difficulty in breathing for up to 24 hours when working every other hour.	Soldiers can perform heavy physical labor for up to 24 hours with rest breaks every hour.	3	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 020

SECURITY CLASSIFICATION: Unclassified

TITLE: Synthesized speech rate and pitch effects on intelligibility of warning messages for pilots. Human Factors, 26, 509-517.

AUTHOR(S): Carol Simpson and Kristine Marchionada - Frost

ORGANIZATION (AGENCY)

LOCATION:

DATE: 1984

SUBJECT. Nine pilots engaged in a computer game flying task while listening for synthesized voice threat warnings which varied in speech rate (123, 156, 178 wpm) and pitch (70, 90, 120 hz) and were presented in a background of simulated helicopter cockpit noise

NATURE OF RESEARCH:	CLE X	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 020	20.1 There were no differences for the three speech rates (123, 156, or 178 wpm) or the three pitches (70, 90, 120 hz) for intelligibility scores (range 98.7% to 99.8% correct) (Intelligibility was defined as reporting the content of the message but not necessarily verbatim).			
	20.2 Response time was significantly faster (m=2.8 sec) for the 178 wpm conditions than for the 123 or 156 wpm conditions (m=3.45 sec).	Although soldiers in the AFV may be able to understand many different types of synthesized speech, they may be able to react faster to speech which is presented at a rate of 178 wpm than a rate of 123 or 156 wpm. Alternatives to speeding up speech include reducing the amount of redundant information. However, research cited in the present article indicates that this may also increase response time.	1	1
	20.3 Pilots preferred the 156 wpm rate to the 178 wpm rate. Pilots felt that with high workload they might miss part of a message. However, their intelligibility scores indicate that with the workload at the present level they were able to understand the messages.	A synthesized speech rate of 178 wpm may overload AFV soldiers in times of high workload. A synthesized speech warning system which could repeat a message, adjust speech rate for level of workload or give redundant visual information may be useful. The level of rapid message processing is dependent also on the degree to which the soldier is trained and familiar with the vocabulary and accent of the synthesizer.	1	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 021

SECURITY CLASSIFICATION: Unclassified

TITLE: Principles of S-C R compatibility with spatial and verbal tasks: The role of display-control location and voice-interactive display-control interfacing. Human Factors, 26, 533-543.

AUTHOR(S): Christopher Wickens, Michael Vidulich, and Diane Sandry-Garza

ORGANIZATION (AGENCY):

LOCATION:

DATE: 1984

SUBJECT: Ten subjects performed tasks which were spatial in nature (tracking) or verbal in nature (system function checklist) in two experiments to determine the optimal interfacing between verbal and spatial tasks with displays and controls.

NATURE OF RESEARCH: CLE X CFE ___ FOM ___
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MILITARY FUNCTION: OP X MA ___ SU ___

MAJOR RISK AREA: EN ___ IP X MA ___ CO ___ OH ___

TYPE OF DATA: QT X QL ___ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO X HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 021	21.1 Performance was superior when verbal information was presented to the right of a spatial tracking task than vice versa and responses were made with a joy stick in the left hand for the tracking task and by pressing a button with the right hand for the verbal task than vice versa. The results are discussed in terms of brain hemispheric compatibility. Processing of verbal information should be superior if the information is provided direct access to the left side of the brain (right side of the body). Processing of spatial information should be superior if the information has access to the right side of the brain (left side of the body).	For AFV soldiers under tremendous workload, information processing may be more efficient if verbal information is displayed to the center or right of a console and if only one hand can be used to respond to the verbal information, it should be the right hand. By the same token, spatial information should be displayed to the center or left of a console and, if the soldier is under high workload, the left hand should be used to respond to the spatial information.	3	2
	21.2 Performance was poor when spatial information was presented auditorily (using different tones) as opposed to visual presentation.	In displaying spatial information, the use of auditory presentation should be avoided.	3	2
	21.3 Performance was faster when a cognitive checklist task was presented auditorily and responded to verbally than when presented visually and responded to manually. Also, subjects could perform both a checklist and a spatial task together better when the two tasks did not share common resources (i.e. visual input, manual output) as when they did share common resources.	The results from this experiment can be used to determine which input or output modalties to use (visual versus auditory, and manual versus speech) for displaying or responding to information. For tasks which are primarily verbal, auditory input and speech output produces good performance. For primarily spatial tasks, visual input and manual output should be used. Also, when two tasks require the same resource, and are both difficult, performance on one or both of the tasks will tend to decline.	3	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 022

SECURITY CLASSIFICATION. Unclassified

TITLE: Are smart tankers better? AFQT and military productivity *Armed Forces & Society*, Vol 12, No 2,

AUTHOR(S) B L , Scribner, A D Smith and R H Baldwin

ORGANIZATION (AGENCY)

LOCATION

DATE 1986

SUBJECT The Seventh Army Training Center conducted a standardized Tank table 8 course for 1,131 crew equipped with M60s and M1s consisting of a total of 13 engagements

NATURE OF RESEARCH	EXP	_	CFE		FOM	X			
	SIM	_	MOD	_	EJ	_			
MILITARY FUNCTION	OP	X	MA	_	SU	_			
MAJOR RESH AREA	C	_	IP	X	MA	_	CO		OH
TYPE OF DATA	QT	X	QL		ST	_			
AFV RELEVANCE	NO	_	SL		MO	_	HI	X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 022	Using the AFQT score as a measure of soldiers' quality, it was found that:			
	22.1 Gunner's as well as Tank Commander's (TC) aptitude, as measured by the AFQT has a direct positive relationship to crew Performance (Hits on a Table 8 exercise). It has been estimated, based on these results that a switch from a cat IV (20th percentile) TC to a cat I (60th percentile) will result in a performance increase of approximately 20.3%.	This finding has implications for AFV soldier selection.	1	2
	22.2 The type of tank used made a difference in performance (M60 VS M1). It has been estimated that moving from an M-60 series tank to an M-1 will increase the average crew's score by 46.7%. The author adds that because the M-1 might be easier to operate this does not preclude the need for smart tankers because under degraded conditions, smart tankers might make the difference in performance.	This finding has implications for AFV design.		
	22.3 Time in the service did not seem to have a significant effect on crew scores. leading the author to speculate that low aptitude gunners or tankers might not significantly improve with increasing time in the service.			

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 022	22.4 Time in a position is important to crew performance. However the authors point out that if the average time in position (7 months) were doubled, it would only increase crew score by about 2%. However, if a soldier's time in position is only two months, doubling that time would increase crew score by about 11.5%. The advantage of having smarter tankers is illustrated in the tables below: Table 1 Percentage of Increase in Tank Equivalent Kills by Mental Category.			

Type of Tank	Gunner & TC Mental Category I	II	IIIA
M60	75.17%	62.84%	45.9%
M-1	18.9%	16.3	12.4%

Type of Tank	Gunner & TC Mental Category IIIB	IV
M60	27.9%	BASE
M-1	8.0%	CASE

AFV DATA COLLECTION SHEET

<u>DOCUMENT IDENTIFICATION NUMBER</u>: IP 023

<u>SECURITY CLASSIFICATION</u>: Unclassified

<u>TITLE</u>: Binocular scanning performance for soldiers wearing protective masks - II.

<u>AUTHOR(S)</u>: D.M. Harrah

<u>ORGANIZATION (AGENCY)</u>: U.S. Army Human Engineering Laboratory (Technical Memorandum 14-85)

<u>LOCATION</u>: Aoerdeen, MD.

<u>DATE</u>: September, 1985

<u>SUBJECT</u>: Three conditions were used in the present experiment; no mask, protective mask with and without combat spectacles (Repeated). Standoff Distance and FOV with M19 binoculars.

<u>NATURE OF RESEARCH</u>:	CLE _X_	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
<u>MILITARY FUNCTION</u>:	OP _X_	MA ___	SU ___		
<u>MAJOR RISK AREA</u>:	EN ___	IP _X_	MA ___	CO ___	OH ___
<u>TYPE OF DATA</u>:	QT _X_	QL ___	SJ ___		
<u>AFV RELEVANCE</u>:	NO ___	SL ___	MO _X_	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 023	23.1 Compared to a no mask condition, the time required to scan a target was significantly degraded by the use of combat spectacles or protective masks. The mean scanning time for the no mask, spectacles and masks conditions were the following: Mask Condition: / Scanning Time No Mask 26.34 Spectacles only 30.25 XM40-1 50.23 XM40-2 44.57 XM40-3 47.13 M17 43.94 XM40-1 w/spectacles 47.23 XM40-2 w/spectacles 48.47 XM40-3 w/spectacles 50.49 M17 w/inserts 46.09			
	23.2 Standoff distance, which is the distance between the eye of the soldier and the lens of the mask he is wearing, was a better predictor of scanning performance than field of Vision (FOV).	Degraded scanning time evidently reduces soldier effectiveness thereby jeopardizing the mission. Scanning time may be degraded further in an encapsulated condition where the soldier's field of vision may be greatly reduced. Following options might be explored toward reducing scanning time with protective masks:	2	2

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 023		a) Improvement in protective mask design which might reduce standoff distance. b) explore various scanning techniques which might compensate for standoff distance.		

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 024

SECURITY CLASSIFICATION: Unclassified

TITLE: The gideon criterion: The effects of selection criteria on soldier capabilities and battle results.

AUTHOR(S): R.J. Wallace

ORGANIZATION (AGENCY): U.S. Army Recruiting Command Research, Studies and Evaluation Division Program Analysis and Evaluation Directorate. (USAREC Research Memo 82-1).

LOCATION: Fort Sheridan, IL.

DATE: January, 1982

SUBJECT: Tank gunnery performance of tank crews were correlated with crew aptitude (AFQT score). Armor battles were simulated and performance effectiveness (between Blue and Red platoons) correlated with varying TC's mental category.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM ___		
	SIM X	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 024	24.1 The best predictor of crew gunnery performance was the Tank Commander's (TC) AFQT score.			
	24.2 When The TCs in Blue and Red are CAT II, the kill rate achieved is 7.45 Red to 1 Blue.	Although greater sophistication in weaponry may give the Blue forces a slight advantage against the larger numbers of the Red forces, it is evident that the greater contribution to performance would be achieved by greater aptitude of the Blue TC.	1	1
	24.3 If the Blue TC is of a lower CAT (IV), the kill rate is 1.33 Red to 1 Blue. This represents an 82% degradation in performance.			
	24.4 If the Red TC is reduced to a CAT IV and the Blue is at a CAT II the kill rate is 11.5 Red to 1 Blue.			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 025

SECURITY CLASSIFICATION. Unclassified

TITLE: Keeping track of many things.

AUTHOR(S): R A. Monty

ORGANIZATION (AGENCY). U.S. Army Human Engineering Laboratory (Technical Memorandum 29-74).

LOCATION: Aberdeen, MD

DATE. November, 1974

SUBJECT: A number of studies are reviewed to investigate how people keep track of many stimuli

NATURE OF RESEARCH:	CLE X	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION.	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 025	The literature reviewed seems to point to the following: 25.1 Irrelevant materials tend to disrupt the rehearsal stage of processing more than the encoding stage. 25.2 Information intake seems to be constant.			
	25.3 If keeping-track tasks are paced at a relatively fast rate it is best to keep the on-time very short relative to the interval between the stimuli. By contrast if the keeping-track pace is kept relatively slow, it is preferable to keep the on-time long relative to the off-time.	These experiments are relevant to information display (e.g., rate of presentation). Given the increasing technology in modern warfare much information will be exchanged verbally or visually (e.g., CRT). The correct encoding, processing storage and recall of such information will require that particular attention be paid to such factors as the design of electronic information media including equipment which will assist the soldier in keeping track of information more efficiently. This is particularly important during instances of continuous operations and/or operations in a degraded mode.	1	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 026

SECURITY CLASSIFICATION: Unclassified

TITLE: Cognitive performance during successive sustained physical work episodes. Behavior Research Methods, Instruments, & Computers, 17, 75-85.

AUTHOR(S). C E. Englund, D.H. Ryman, P. Naitoh, and J.A. Hodgdon

ORGANIZATION (AGENCY):

LOCATION:

DATE: 1985

SUBJECT: The effects of physical work, sleep loss and time of day on cognitive performance were assessed on a small group of volunteer marine reconnaissance personnel during a five day period.

NATURE OF RESEARCH:	CLE X	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 026	26.1 Sustained exercise was found to have a differential effect on soldier's performance according to the task. a) No real effect was found for physical work upon map memory. b) The non-exercise group was able to remember the details of a recently read passage slightly better then the exercise group. c) moderate exercise while attending to a CRT may extend target detection performance levels and may limit the performance decrement when it occurs. d) The sustained exercise group showed decreased performance in word memory and simple addition. e) Slight improvement in performance occurred for an "Air Defense" game. Authors note that competition and interest may motivate toward better performance or at least diminish decrements during sustained exercise or sleep loss. 26.2 Sleep deprivation affected the performance of individuals on various tasks.		1	1

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 026	a) Soldier's ability to correctly detect specific targets on a vigilance task decreased by 10% on the 2nd continuous work day.			
	b) Soldier's ability to correctly identify objects of different shapes also decreased by 10%.			
	c) Their memory for irregular shapes decreased 10% by the second day of continuous work.			
	26.3 Time of day had some significant effects on performance. The effects of time of day on performance were seen as being equivalent to the individual's circadian rhythm.	Competition and interest seem to diminish the decrement levels in cognitive performance. These results indicate that appropriate work-rest schedules conforming to the soldier's circadian rhythm may be one method to reduce performance degradation.		
	a) ability to make rapid choices decreased by 7 % in the early morning hours.			
	b) Information and motivation were shown to overcome the effects of time of day.			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 027

SECURITY CLASSIFICATION: Unclassified

TITLE: Selection of remotely labeled switch functions during dual task performance. In R.C. Sugarman (Ed.), Proceedings of the Human Factors Society 25th Annual Meeting. Santa Monica, CA: Human Factors Society.

AUTHOR(S): Stephen B. Hottman

ORGANIZATION (AGENCY).

LOCATION:

DATE: 1981

SUBJECT: This study evaluated the ability of 18 subjects to use three different types of controllers, which could not be seen, to select menus on an interactive display. Engineering students were positioned in a 50° reclining position (to simulate high G force flight positioning) and performed a tracking task while making menu selections (selecting different 3 digit number sequences). The menu selections were made using either a joystick, a 2X4 keyboard or a 3X3 keyboard connected to monitors with a spatial analog of the controller the subject was using.

NATURE OF RESEARCH:	CLE X	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	OT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 027	27.1 There were no differences in mean response times for the three controllers. Mean response time (in seconds) for: Joystick - 3.37, 3X3 Keyboard - 3.20, 2X4 Keyboard - 3.58. There were also no differences on the tracking task indicating that response times were not a function of differential allocation of resources to the two tasks across the three conditions.	Menu systems (displaying information not frequently needed) offer a method to reduce the number of monitors (thus reducing space requirements) used for a system. When the controller can not be seen, it makes little difference in terms of response time whether a joystick, a 3X3 or a 2X4 keyboard is used to select different options from the menu system.	2	2
	27.2 Significantly more positioning errors (incorrect choices) were made using the Joystick controller than the two keyboard devices. Average number of positioning errors for: Joystick - 3.33 (12.3%), 3X3 keyboard - 0.77 (2.8%), 2X4 keyboard - 0.74 (2.67).	Although menu selection response times may not be different for different controllers, more errors are made using a joystick type controller than a 2X4 or 3X3 keyboard. Care should be used in choosing 1) the type of interface to use with a menu system and 2) the information displayed on such a system (often used information should probably be presented on its own display).	2	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: IP 028

SECURITY CLASSIFICATION: Unclassified

TITLE: Human factors development test (DT II) of the XM30 protective mask series.

AUTHOR(S): J.A. Barnes, W.E. Hanlon, D.M. Harrah, and R.P. Merkey

ORGANIZATION (AGENCY): U.S. Army Human Engineering Laboratory (Technical Memorandum 4-83)

LOCATION: Aberdeen, MD.

DATE: March, 1983

SUBJECT: Three mask conditions were used in this study·no mask, protective mask with and without combat spectacles (Repeated). Nine sets of tests were preformed: Mobility/Portability, Small Arms, Armored Vehicle, Visual Performance, Donning Tests, Sleep-In Test, Drinking Test, Combat Spectacle Fitting and Gas Chamber.

NATURE OF RESEARCH:	CLE ___	CFE X	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP X	MA ___	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 028	<u>Mobility/Portability</u>			
	28.1 No significant differences with or without protective mask occurred in this condition.			
	<u>Small Arms</u>			
	28.2 No significant differences occurred in participants' ability to obtain and strike targets with or without protective masks.	Discomfort caused by combat spectacles due to improper fit of spectacles on nose bridge of participant.	2	2
	28.3 Ability to strike targets was enhanced under protective mask conditions.	Enhancement in ability to strike targets under protective mask conditions might be due to greater confidence in shooting weapon producing recoil or blowing debris into gunner's face, when the latter is protected.		
	<u>Armored Vehicle</u>			
	28.4 Tankers reported no significant differences in the performance of the tasks they had been assigned.	The major complaint was an increase in glare when the combat spectacles were worn.	1	2
	NOTE: No quantitative measures of performance were provided for the various tasks assigned.			

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 028	<u>Visual Performance</u>			
	28.5 "The antilaser goggles, in their present form, greatly degrade the soldier's ability to see under good lighting conditions." (Efforts are being made to correct deficiency).		1	2
	NOTE: Although loss in visual perimeter was reported, author states that such loss may not have significant impact on tactical performance.			
	<u>Donning Test</u>			
	28.6 Soldiers donned the protective mask (XM34) with spectacles faster than the XM34 alone. The difference was not statistically significant	Difficulties reported in donning the protective mask might require redesign of mask and hood to diminish mask donning errors, if standard of 9 secs is to be met.	1	2
	28.7 Fastest donning times were achieved when hood was worn around the neck.			
	28.8 Slowest donning times were achieved when hood was set as recommended by the Armor Board.			
	28.9 Hood was consistently donned upside down, inside out or sideways.			
	NOTE: Although U.S. Army doctrine recommends that protective mask be donned in 9 secs., under no condition was that time achieved.			

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 028	Squad Dismount			
	28.10 Essentially no significant differences occurred for any of the protective conditions.		2	2
	Sleep-In Test (in a simulated chemically contaminated environment)			
	28.11 Approximately a 33% casualty rate occurred due to soldiers removing their mask because of discomfort. Some soldiers unconsciously removed their mask during sleep.	Lack of fit/comfort of the protective mask might have stressful effect on soldiers not only because of pain/discomfort experienced, but also because of stress generated by fear of falling asleep since discomfort might be increased. A common occurrence follows: rolling over canister and cutting off air.	1	1
	NOTE: The author notes that test monitors report that had the chemical simulant been a real agent they strongly feel that some of the soldiers would have preferred to endure some discomfort instead of exposing themselves to a life-threatening situation.			
	Drinking Test.			
	28.12 Statistically significant difference in drinking 250 ml of water using XM30 (61.7 secs.) vs M17A1 (79.1 secs.).		1	2

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IP 028	<u>Combat Spectacle Fitting.</u> 28.13 Sizes of combat spectacles available did not meet requirement to properly fit the soldiers; soldiers complained of moderate to severe pain caused by the tightness of the combat spectacle bridge. NOTE: The author recommended that size 27 bridge be added to those available for combat spectacles. Also recommends that other lens sizes be provided to fit a greater range of soldiers. <u>Overall Conclusion.</u> 28.14 Combat spectacles are fully compatible with the XM30 and XM34 protective masks. 28.15 Only in TOW vehicle performance was there degradation in field of view (FOV). 28.16 Combat spectacles were not found to degrade protection to the soldier by XM30 series protective masks. 28.17 Major problem encountered with the combat spectacle was comfort/fit.	Lack of fit/comfort of the combat spectacles.	1	1

CONTINUOUS OPERATIONS (CO)

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 001

SECURITY CLASSIFICATION: Unclassified

TITLE: Sleep loss and its effect in combat

AUTHOR(S): Major Henry L. Thompson

ORGANIZATION (AGENCY): Center for Leadership & Ethics USACGSC

LOCATION: Fort Leavenworth, Kansas

DATE: September, 1983

SUBJECT: A review of the effects of sleep loss with implications for soldier performance and suggestions to counteract problems.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ _X_		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA ___	CO _X_	OH ___
TYPE OF DATA:	QT _X_	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL _X_	MO ___	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 001	1.1 Errors of omission rather than commission are made for vigilance tasks with sleep loss.	Unless signal is very salient soldier may miss it.	3	2
	1.2 Decrease in ability to divide attention occurs with sleep loss.	Critical tasks should not overlap	3	2
	1.3 Memory becomes faulty.	Soldiers may have difficulty learning or remembering new information or following instructions.	3	2
	1.4 Response to instructions or events slow with reduced sleep.	Develop decision aids to reduce cognitive load.	3	2
	1.5 Ability to encode & decode information becomes degraded.	Same.	3	2
	1.6 Logical reasoning is degraded.	Same.	3	2
	1.7 Communication degrades.	Simplify and reduce communications.	3	2
	1.8 Mood changes occur.		3	3

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 002

SECURITY CLASSIFICATION: Unclassified

TITLE: Continuous operations; who melts, when and why? paper presented to 1980 conference of the Inter-University Seminar on Armed Forces and Society.

AUTHOR(S): Frederick J Manning and Larry Ingraham

ORGANIZATION (AGENCY): U.S Army Medical Research Unit-Europe

LOCATION: HQ 7th Medical Command Heidelberg, West Germany

DATE: October, 1980

SUBJECT: Observations of field artillery units in sustained operations with emphasis on social variables rather than performance.

NATURE OF RESEARCH:	CLE ___	CFE ___	FON _X_		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA ___	CO _X_	OH ___
TYPE OF DATA:	QT ___	QL ___	SJ _X_		
AFV RELEVANCE:	NO ___	SL _X_	MO ___	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 002	2.1 Officers and NCO's remained awake for entire operation even when there was no work to perform. This produced performance deficits later.	In continuous operations, officers assume a large amount of responsibility and forgo rest which could possibly jeopardize troops.	3	2
	2.2 Requests for fire from forward observers did not degrade. Plotting of potential targets, pre-planned fire, setting up camouflage nets did degrade.	Continuous operations lead to deficits in self paced activities but not forced paced activities.	3	3
	2.3 Performance by enlisted men fell off quickly. Very low cohesiveness.	Stress of continuous operations and low level of cohesion leads to poor performance.	3	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 003

SECURITY CLASSIFICATION: Unclassified

TITLE: Soldier performance in continuous operations

AUTHOR(S): F. Kopstein, A. Siegel, H. Ozkaptan, F. Dyer, J Conn, W. Slifer and J. Caviness

ORGANIZATION (AGENCY): Applied Psychological Services

LOCATION: Wayne, PA.

DATE: April, 1982

SUBJECT: Computer simulation of performance for mechanized infantry, armor and artillery units in continuous operations with continuous adverse conditions and no use of countermeasures.

NATURE OF RESEARCH: CLE ___ CFE ___ FON ___
SIM _X_ MOD ___ EJ ___

MILITARY FUNCTION: OP _X_ MA ___ SU ___

MAJOR RISK AREA: EN ___ IP ___ MA ___ CO _X_ OH ___

TYPE OF DATA: QT _X_ QL ___ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO ___ HI _X_

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 003	3.1 Mechanized Infantry.		1	1
	3.1.1 Squad leader performance after 1 day drops to 55%* then drops another 20% and 15% for consecutive days.	Command and control performance drop drastically during continuous operations. Simplify and reduce cognitive demands.		
	3.1.2 Platoon leader performance drops to 77% after 1 day and continues to drop 15% and then 12% each day thereafter.	Force preservation & regrouping performance also degrade at a high rate.	1	1
	3.1.3 Gunner/carrier team leader performance drops to 79% after 1 day and then 15% and 10% each day thereafter.	Combat activity performance degrades but not to extent as above.	1	1
	3.1.4 Maneuver team member performance drops to 85% and continues at a rate of about 10% each day thereafter.	Orientation activity does not degrade as rapidly or as much as other tasks.	1	2
	3.2 Armor.			
	3.2.1 Tank Platoon Leader effectiveness drops to 85% after 1 day and continues at rate of 10% a day.	Command and control and target designation & tracking degrade rapidly. Reduce complex psychomotor task or simplify.	1	1
	3.2.2 Tank commander effectiveness drops to 90% and continues at about 8% a day.	Same.	1	1
	*All percentages are predicted changes from baseline performance.			

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 003	3.2.3 Tank gunner performance drops to 97%* and continues at a rate of 5% and then 3% a day.	Preparation and operations of weapons (physical activity) does not degrade much under CONOPS.	?	2
	3.2.4 Tank loader performance drops to 97% effectiveness and then does not drop.	Same.	1	3
	3.3 Artillery.			
	3.3.1 Battery executive officer performance drops to 79% after 1 day and continues at a rate of 20%, 15% and then 10% for each consecutive day.	Command and control performance degrade rapidly. Reduce cognitive load or simplify.	1	1
	3.3.2 155mm gunner performance drops to 84% and then at a rate of 15% and 10% for each consecutive day.	Ammunition logistics degrades rapidly. Develop aids to assist.	1	1
	3.3.3 Howitzer section chief performance drops to 86% after 1 day and then at a rate of 15% and 10% each day thereafter.	Safety and communications degrade rapidly.	1	2
	3.3.4 155mm crewmember performance drops to 95% after 1 day and then at a rate of 5% each day thereafter.	Orientation and preparation degrade very little.	1	3
	3.4 Duty position differences should occur.	More decrements should occur for those tasks requiring high mental activities as opposed to physical activities. Leader performance should suffer more than others.	1	1
	*All percentages are predicted changes from baseline performance.			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 004

SECURITY CLASSIFICATION: Unclassified

TITLE: Field studies of continuous tank operations

AUTHOR(S): L. L. Ainsworth and H. P. Bishop

ORGANIZATION (AGENCY): Human Resources Research Organization (Technical Report 71-16)

LOCATION: Alexandria, VA.

DATE: 1971

SUBJECT: Experimental group of 20 tank crews completed a 12 hour course four consecutive times over 48 hours. Performance was compared to a control group which was given 24 hours rest between course runs.

NATURE OF RESEARCH:	CLE ___	CFE X	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA ___	CO X	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 004	4.1 Few performance differences occurred between control and experimental groups for communication, gunnery and maintenance and two driving exercises	Routine or physical tasks degrade very little. Performance at night is not seriously affected by diurnal rhythms.	1	2
	4.2 Differences were found in moving surveillance and in two driving exercises.	Activities that demand a high level of alertness or require complex perceptual motor activity are most sensitive to lack of sleep. Simplify tasks.	1	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 005

SECURITY CLASSIFICATION: Unclassified

TITLE: Human factors in sustaining high rates of artillery fire.

AUTHOR(S): F. J. Manning

ORGANIZATION (AGENCY): U.S. Army Medical Research Unit

LOCATION: Europe

DATE: 1978

SUBJECT: Using observations, interviews and literature reviews estimations of continuous operations for artillery crew members were made.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM X		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA ___	CO X	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 005	5.1 Continuous artillery fire could continue for an estimated 36 hours. Serious degradation was thought to occur within 24 hours.	Sleep for leaders should have largest impact on continued performance. Cross training should reduce degredation. Unit cohesion should reduce degredation.	2	1

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO O/S	venting performance deficits. This was found true no matter where in the circadian rhythm the nap occurred.			
	8.9 Sleep inertia effects, or performance decrements which occur immediately after awakening from normal sleep and persist for 15-30 minutes, are found to occur for a variety of tasks including cognitive performance tasks as well as tasks requiring physical performance. Naps which occur from 0400 to 0700 produce greater sleep inertia effects than at other times.	If naps are taken around 0400, at least 15-30 minutes of recuperation or light work should be given before tasks of a critical nature are undertaken.	1	1
	8.10 In SUSOPS using MOPP gear, accuracy was maintained at the expense of speed. Infantry fighting vehicle crews in MOPP gear were found to last 60 hours (equal to a control condition) when they were given rest breaks, suit changes and food every 6 hours as well as a 6 hour sleep period. In contrast, when all of these factors, except sleep periods were removed, the crews lasted from 31.4 to 37.9 hours.	The use of rest breaks, food and MOPP suit changes are effective means to increase CUNOPS duration.	1	1
	8.11 With normal sleep the night before, the average person has a sleep latency (how long it takes to fall asleep) 10-12 minutes. With 1 or 2 nights without sleep this drops to 1 or	Sleep debt is cumulative and can result in severe drowsiness, low alertness and motivation.	2	2

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 008	2 minutes. With no sleep in 3 or more days, this latency is less than a minute. If a reduced amount of sleep is taken over a week or so period, sleep latency is also reduced to less than a minute.			
	8.12 Cognitive performance can be maintained indefinitely with 6 to 8 hours of sleep. 3 to 4 hours of sleep a night will maintain performance for 5-6 days. Less than 3 hours of sleep will lead to rapid decline in military effectiveness.		1	1
	8.13 Interviews with 24 leaders who had NTC rotational experience produced the following results: 8.13.1 Did CONOPS significantly degrade performance of command control and communications personnel in battalion headquarters? Yes: 5, No: 19. 8.13.2 Did CONOPS significantly affect performance of the scout platoons? Yes: 5, No: 6, NA:13; The support platoons? Yes: 6, No: 3, NA: 15. 8.13.3 At what hours were the effects of CONOPS most apparent? 0300-0500 and 1500 to 1700. 8.13.4 Was the flow of information significantly affected by CONOPS? Yes: 13, No: 8, NA: 3.	Performance declines occurred at the circadian rhythm low points. Information flow was disrupted as well as the perform- of the scout and support platoons. Fatigue was probably reduced by the use of planning, effective leadership, desemination of responsibilities, use of shifts, and the use of standardized reports and formats.	1	1

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 008	8.13.5 Would you reorganize command and communication sections, scout and support platoons to decrease effects of CONOPS? Yes: 9, No: 13, NA: 2. 8.13.6 Did you feel CONOPS had a significant impact on your unit while accomplishing your mission? Yes: 4, No: 15, NA: 5. 8.13.7 Did the unit use standard reports and formats so as to eliminate confusion during CONOPS? Yes: 6, No: 0, NA: 0. 8.13.8 Did the CDR and staff consider the unit fatigue factor in the planning process? Yes: 5, No: 1, NA: 0. 8.13.9 Was leadership a decisive factor in overcoming fatigue? Yes: 6, No: 0, NA: 0. 8.13.10 Did the TOC use shifts to maintain CONOPS? Yes: 6, No: 0, NA: 0. 8.13.11 Were 2ICS allowed to assume routine functions freeing leaders for critical events? Yes: 6, No: 0, NA: 0. 8.13.12 Did the TOC maintain accountability of the rest factor of major units including scouts, mortars, GSR etc.? Yes: 0, No: 6, NA: 0.			

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 008	8.13.13 Did the unit maintain communications on a 24 hr continuous basis? Yes: 6, No: 0, NA: 0.			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 009

SECURITY CLASSIFICATION: Unclassified

TITLE: Prolonged heavy vehicle driving performance. Effects of unpredictable shift onset and duration and convoy versus independent driving conditions.

AUTHOR(S): R. G. C. Fuller

ORGANIZATION (AGENCY): U.S. Army Research Institute (Technical Report 585)

LOCATION: Alexandria, VA.

DATE: September, 1983

SUBJECT. In 2 experiments, subjects drove 7-ton Bedford rigid trucks continuously for 4 consecutive days for 11 hours each day from either 0900 to 2030 or from 1500 to 0230 with a 30 min meal break. In one experiment, subjects drove in a convoy, while in the other experiment subjects drove in a normal manner

NATURE OF RESEARCH.	CLE ___	CFE X	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP ___	MA ___	SU X		
MAJOR RISK AREA:	EN ___	IP ___	MA ___	CO X	OH ___
TYPE OF DATA:	QT X	QL X	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 009	9.1 Time headway (time it takes a following vehicle to reach a leading vehicle if the leading vehicle stops dead) when not driving in a convoy was not thought to be different on the late shift (1500 to 0230) than on the early shift (0900 to 2030) Mean: 3.00 seconds. No noticeable degradation in performance occurred over time.	Driving performance (in terms of riskiness) does not deteriorate when rest breaks are given and shifts are used in normal driving.	2	2
	9.2 Mean time headway in a convoy was longer on the late shift (1.93 seconds) than on the early shift (1.62 sec.) and was longer for the first hour for both shifts (2.62 seconds) than for all other hours (range =1.52 to 1.79 sec.). There was no other decrement over time.	The first hour of driving in a convoy appears to be an adjustment period to the performance of the lead vehicle. Drivers on late shifts compensate for the problems of driving at night by increasing headway time. Driving performance does not degrade over time.	2	2
	9.3 Time headway is shorter when in a convoy either on the late shift (1.93 sec.) or on the early shift (1.62) than normal driving (3.00 sec.).	Convoy lead vehicles are presumed to be more predictable than normal drivers.	2	2
	9.4 Steady state following and closing account for 95% of driving time, braking accounts for the other 5%.		3	3
	9.5 There were no differences of subjective sleep quality or the amount of time men slept for the two shifts. Subjects in the early shift were drowsy in the beginning of their shift, while subjects	Driving performance over 11 hours, is not affected by drowsiness, exhaustion, boredom, irritation or level of awareness.	2	2

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 009	in the late shift were more markedly drowsy at the end of the shift. No differences were found for exhaustion, boredom, irritation, or ratings of awarness.			
	9.6 Older drivers and late shift drivers were less prepared to drive longer than were younger and early shift drivers.	Driving a late shift reduces motivation level. Age may also be a factor in reduced motivation.	2	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 010

SECURITY CLASSIFICATION. Unclassified

TITLE: Background data for the human performance in continuous operations guidelines.

AUTHOR(S): Mark Pfeiffer, Arthur Siegel, Stanley Taylor, and Lucius Shuler, Jr.

ORGANIZATION (AGENCY): U.S. Army Research Institute (Technical Report 386).

LOCATION: Alexandria, VA.

DATE: July, 1979

SUBJECT: Review of literature on the effects of stressors on human performance, critical tasks were identified for continuous operation of mechanized infantry combat teams, and a policy capturing model was presented.

NATURE OF RESEARCH: CLE ___ CFE ___ FOM ___
SIM ___ MOD _X_ EJ ___

MILITARY FUNCTION: OP _X_ MA ___ SU ___

MAJOR RISK AREA: EN ___ IP ___ MA ___ CO _X_ OH ___

TYPE OF DATA: QT _X_ QL ___ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO _X_ HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 010	10.1 Poulton (1970) found that a loss of 5 hours of sleep on one night or 2.5 hours on two nights is sufficient to produce missed signals on an auditory vigilance task.	The effects of sleep deprivation are cumulative. Vigilance tasks suffer large degradations even with only moderate sleep loss.	2	2
	10.2 Intermittent performance of tracking tasks over a 48 hour period without sleep results in an increase of errors of 120% over baseline. Stimulants can reduce this back to baseline performance.	Fine motor movements degrade with sleep loss. Mechanisms should be designed to allow for this effect.	2	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 011

SECURITY CLASSIFICATION: Unclassified

TITLE: The effects of continuous military operations on selected military tasks.

AUTHOR(S): James Banks, Jack Sternberg, John Farrell, Charles Deborw, William Dalhamer

ORGANIZATION (AGENCY): U.S. Army Behavioral and Systems Research Laboratory (Technical Research Report #66)

LOCATION: Arlington, VA.

DATE: December, 1970

SUBJECT: In a field study, 61 subjects were continuously tested over a 48 hour period to determine the degradation of performance on target acquisition with the Starlight scope, rifle shooting, and grenade-throwing accuracy.

NATURE OF RESEARCH:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA ___	CO _X_	OH ___
TYPE OF DATA:	QT _X_	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI _X_	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 011	11.1 20% of targets (of 48 targets presented) were detected with the Starlight scope under starlight conditions on day 1 and day 2. 54% of the targets were detected under a full moon on day 1 and 61% were detected on day 2. On day 1 it took an average of 56 seconds to detect the targets under starlight conditions and 44 seconds on day 2. On day 1 it took an average of 50 seconds to detect the targets under a full moon, and 43 seconds on day 2.	The detection of targets with the Starlight scope did not degrade over 48 hours. This could be due to the heightened arousal associated with being in an experiment. Heightened arousal can counteract the effects of sleep deprivation. The use of cat naps may have also helped performance.	1	1
	11.2 Soldiers firing 20 rounds at 100 meters in the morning hours scored an average of 83 (out of a possible 100) on day 1 and 83 on day 2. At 200 meters, scores were 54 on day 1 and 55 on day 2. At 300 meters, scores were 36 on day 1 and 39 on day 2.	No degradation was found to occur for this fine hand-arm motor response task in daylight hours. Again, heightened arousal or motivation may have reduced the effects of sleep loss as well as the use of short naps.	1	1
	11.3 Soldiers throwing 10 grenades at 15 meters in daylight hours scored an average of 37 (out of a possible 80) on day 1, and 37 on day 2. At 20 meters, soldiers scored an average of 34 on day 1 and 34 on day 2. At 25 meters, soldiers scored an average of 30 on day 1 and 31 on day 2.	No degradation was found to occur in daylight hours for grenade throwing which requires gross motor responses and strength. These results indicate that the use of short naps and increasing motivation can attenuate the effects of sleep loss.	1	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 012

SECURITY CLASSIFICATION: Unclassified

TITLE: Physical fitness as a moderator of cognitive work capacity and fatigue onset under sustained combat-like operations.

AUTHOR(S): Robert Pleban, Debra Thomas, Henry Thompson

ORGANIZATION (AGENCY): U.S. Army Research Institute (Technical Report 687)

LOCATION: Alexandria, VA.

DATE: June, 1985

SUBJECT: 16 ROTC cadets performed a 2 1/2 day Pre-Ranger Evaluation exercise. Prior to the test, the cadet's overall level of fitness was assessed using 5 fitness measures. Cognitive performance and subjective measures of fatigue before, during and after the exercise were correlated with fitness.

NATURE OF RESEARCH: CLE ___ CFE _X_ FOM ___
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION: OP _X_ MA ___ SU ___

MAJOR RISK AREA: EN ___ IP ___ MA ___ CO _X_ OH ___

TYPE OF DATA: QT _X_ QL ___ SJ ___

AFV RELEVANCE: NO ___ SL _X_ MO ___ HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 012	12.1 More encoding or decoding of bigrams and grid coordinates were attempted and more were performed correctly after 2 days of continuous operations for cadets who were in better fitness than those who were not. Other cognitive tests (Map-plotting and logical reasoning) did not demonstrate significance in the expected direction.	The effect of fitness on continuous performance probably does not demonstrate itself unless the task is sustained at least 6 minutes and the effects of sleep loss have built up.	2	2
	12.2 Only one subjective measure of fatigue was found to be significantly negatively correlated with fitness level after 2 days of continuous operations.	Fitness is only partially related to the build up of fatigue.	2	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 013

SECURITY CLASSIFICATION: Unclassified

TITLE: Military experts' estimates of continuous operations performance (or close but no cigar).

AUTHOR(S): Karen Neff and Robert Solick

ORGANIZATION (AGENCY): U.S. Army Research Institute (Technical Report 600)

LOCATION: Alexandria, VA.

DATE: November, 1983

SUBJECT: Comparisons were made between expert ratings of performance by officers who had had either artillery, infantry or armor experience and data from three previous studies: ENDURE, a study of 48 hour continuous tank crew performance; a laboratory investigation of 48 hour FDC combat operations; and Early Call I and II in which soldiers performed sustained exercises for up to 5 days.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM ___		
	SIM ___	MOD _X_	EJ _X_		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA ___	CO _X_	OH ___
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AFV RELEVANCE:	NO ___	SL ___	MO ___	HI _X_	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 013	13.1 Agreement among officers as to expected performance degradation (inter-rater reliability) was very high for the 50 tasks estimated (mean reliability=.83,sd=.17).	Most of the experts chose similar simplification strategies in order to make predictions.	1	2
	13.2 The experts' judgements were, in most cases, not in agreement with actual performance. Experts tended to over-estimate fatigue on simple motor skills and underestimate fatigue on cognitive and perceptual tasks. They tended to ignore confounding variables such as learning, lighting, diurnal variation.	Experts chose simple but not very accurate heuristics to predict how soldiers would perform in continuous operations. Bootstrapping, which replaces experts with an algebraic model of their own policies, might be more accurate than using the judges themselves.	1	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 014

SECURITY CLASSIFICATION: Unclassified

TITLE: Human performance in continuous operations: Volume I human performance guidelines

AUTHOR(S): Arthur Siegel, March Pfeiffer, Felix Kopstein, Lawrence Wilson, and Halim Ozkaptan

ORGANIZATION (AGENCY): U.S. Army Research Institute (Research Product 80-4A)

LOCATION: Alexandria, VA.

DATE: December, 1979

SUBJECT: Computer simulation using a model previously developed to determine the performance degradation associated with continuous operations of mechanized infantry, armor, and artillery personnel on each of a number of defined critical tasks.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM ___		
	SIM X	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA ___	CO X	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 014	14.1 Cognitive and perceptual tasks which include encoding/decoding, logical reasoning, accurate perception/concentration as well as vigilance tasks are expected to severely degrade within 36 to 48 hours as a result of sleep loss. Also, harsh environmental conditions such as heat, cold, or humidity may hasten the degradation.	The cognitive or perceptual components of tasks could be reduced by training in problem solving, or personnel could be rotated to ease the effects of degradation.	1	1
	14.2 Performance of complex motor tasks will be more severely degraded than simple motor tasks. The exceptions are complex motor tasks which have become routine or overly learned. Routine motor tasks are extremely resistant to sleep loss.	Training of complex motor tasks is an important method for reducing the effects of sleep loss.	1	1
	14.3 Degradation of performance due to sleep loss varies greatly for both position as well as tasks performed in that position. Some tasks degrade slowly, while others degrade much faster depending on the amount of cognitive or perceptual components and the amount of simple or complex motor components involved.	Reduce the amount of cognitive or perceptual components required by personnel to complete tasks.	2	1
	14.4 Redistribution of tasks among personnel does not significantly reduce performance degradation due to sleep loss. Computer projections of reallocations of tasks showed negligible changes in performance.	Methods other than redistribution of tasks should be considered to reduce performance degradation.	1	1

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 014	14.5 For positions whose performance are expected to fall below 90% effectiveness after 48 hours, paralleling tasks (two soldiers performing the same task independently) produced an average of 19.4% increase in effectiveness over baseline from an average of 66.6% to an average of 86% effectiveness.	Paralleling tasks is a useful method for reducing the effects of sleep loss. However this method demands much more manpower than may be available. It would be important to determine in which positions it would be most cost effective to parallel tasks.	1	1
	14.6 The sharing of tasks (in which some steps of a task are carried out by two people) also results in slowing down the degradation in performance due to leep loss. The reduction was on the order of 12.5% for those tasks in which performance degraded below 90% after 48 hours.	Task sharing is an effective method for reducing the effects of sleep loss. This method requires less manpower than parallel performance but requires cross training. It may be more cost effective to share some tasks than parallel the tasks.		
		Some suggested relief or support for critical abilities:		
		Communication - Provide check lists of standard message elements, use standard messages in standard formats requiring only blanks to be filled in, precede message with easily identifiable marker signal, visual signals.	1	1
		Dynamic Precision - Provide rapid dampers for shooting platforms in vehicles, rigid frame work to brace soldier, practice under vibrating conditions.		

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 014		Hearing - Provide earplugs, hearing aids incorporating filters to amplify sounds of threat forces, midrange sensitive, directionally shielded microphones to assure clarity of transmitted verbal signals, use hand, light or cutaneous signals to provide redundant information. Memory - Develop efficient codes, vocabularies, or overtrain SOP's, provide quick look check lists, pictures, or charts, provide note pad or tape recorder, provide nomographs, curves to regenerate needed information. Numerical Facility - Provide calculators or rules of thumb for checking results, proprogram calculators to reduce possibility of forgetting steps. Orientation - Provide maps, charts, grease pencils, compass, pedometer to reduce difficulty in locating position, computerized display of surrounding terrain and present position, provide necessary practice. Perceptual Speed - Provide silhouettes of enemy equipment from different angles, to enhance recognition ability, have computer display and update status of changing elements.		

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 014		Reasoning - Outline of steps leading to solutions for classes of problems, provide decision trees, interactive computer program to accept data and advise on decisions, practice in realistic problems with war gaming. Vision - Provide binoculars, miniture radars, polarizing devices used to enhance target contrast, night vision devices, optical lenses enhancing displacement of moving objects, grid to aid in referencing.		

AFV DATA COLLECTION SHEET

<u>DOCUMENT IDENTIFICATION NUMBER</u>: CO 015

<u>SECURITY CLASSIFICATION</u>: Unclassified

<u>TITLE</u>: Management of stress in army operations

<u>AUTHOR(S)</u>: A. I. Siegel, F. Kopstein, P. Federman, H. Ozkaptan, W. Slifer, F. Hegge and D. Marlowe

<u>ORGANIZATION (AGENCY)</u>: U.S. Army Research Institute (Research Product 81-19)

<u>LOCATION</u>: Alexandria, VA.

<u>DATE</u>: April, 1981

<u>SUBJECT</u>: Recommendations from expert judgment as to the effects of stress and methods for coping with stress.

<u>NATURE OF RESEARCH</u>:	CLE ___	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ _X_		
<u>MILITARY FUNCTION</u>:	OP ___	MA ___	SU _X_		
<u>MAJOR RISK AREA</u>:	EN ___	IP ___	MA ___	CO _X_	OH ___
<u>TYPE OF DATA</u>:	QT ___	QL ___	SJ _X_		
<u>AFV RELEVANCE</u>:	NO ___	SL ___	MO _X_	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 015	15.1 In WWII and Korea ratio of combat intensity (measured by wounded in action) and stress casualties was 4 or 5:1. It is expected that with continuous operations this will be 3:1.	Expect a large number of stress casualties with continuous operations. Effort must be placed on reducing stress casualties.	1	1
	15.2 Reactions to combat stress vary greatly - in WWII elite units had stress casualty rates of 6 to 100 casualties while in other units it was 13 to every 100 casualties.	Leadership and unit identification were thought to keep stress rates down for elite units. Stress is contagious.	1	1
	15.3 Uncertainty increases stress.	Increase flow of information to soldiers.	1	1
	15.4 Leadership and cohesion reduce stress.	Develop trust and confidence in soldiers, leaders, equipment and ones own ability. Give praise, rewards, set realistic goals accentuate positive.		
	15.5 Stress develops slowly. Learn to recognize in self and others.	Teach soldiers to recognize signs of stress.	1	2
	15.6 Physical conditioning raises tolerance to stress, use relaxation, meditation, ventilate feelings.	Teach soldiers methods of coping with stress.	1	1
	15.7 3 principles of combat stress:			
	15.7.1 Immediacy - help soldier at earliest possible time.	If stress is treated early, it may not become a problem.		
	15.7.2 Proximity - treat soldier close to primary group.	Easier for soldier to return to duty if treated by primary group.		

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 015	15.7.3 Expectancy - expect soldier to return to work	Soldier will pick up on expectations and and try to meet them.		
	15.8 In continuous operations, sleep time must be scheduled for each soldier or else stress will quickly build up.		1	1
	15.9 Allocate tasks fairly, fit man to the task, parallel tasks, use task sharing and cross training to reduce the effects of stress.	Use these methods of task management to reduce effects of stress.	1	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER. CO 016

SECURITY CLASSIFICATION Unclassified

TITLE. The military performance of soldiers in continuous operations: Exercises "Early Call" I and II. In L. Johnson, D. Tepas, W. Colquhoun, and M. Colligan (Eds.), Biological rhythms, sleep and shiftwork. Jamaica, NY: Spectrum Publications.

AUTHOR(S): Diana Haslam

ORGANIZATION (AGENCY):

LOCATION:

DATE: 1981

SUBJECT: In Early Call I three platoons with a total of 68 parachutists performed an extensive number of tasks designed to measure military, cognitive and physiological degradation of 0, 1.5 and 3 hours of sleep in each 24 hours over a 9 day period. Similar dependent measures were taken in Early Call II. However, the 10 subjects in this study performed with no rest for 90 hours and then for the next 6 days they were given a 4 hour block of rest every 24 hours.

NATURE OF RESEARCH.	CLE ___	CFE X	FOM ___		
	SIM ___	MOD ___	EJ X		
MILITARY FUNCTION:	OP X	MA ___	SU X		
MAJOR RISK AREA:	EN ___	IP ___	MA ___	CO X	OH ___
TYPE OF DATA.	QT X	QL ___	SJ X		
AFV RELEVANCE	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 016	16.1 In Early Call I, All of the subjects in the 0 hour sleep group withdrew after 4 days, 39% of the 1.5 hour sleep group withdrew after 5 days, and 91% of the 3 hour group completed the exercise.	With at least 1.5 to 3 hours of sleep, soldiers can remain functioning for 5 to 9 days.	1	1
	16.2 In a vigilance shooting task in which 9 targets were presented for 5 seconds over a 20 minute period, performance was worse for the 3 groups over the experimental days (m=1-6.5hits) as compared to control conditions (m=5.5-8.5 hits).	Slow event tasks will show marked deterioration after only 24 hours of sleep loss.	1	1
	16.3 In a task requiring the grouping of 5 shots together, performance did not deteriorate for the 3 groups over the experimental days.	This short duration, fine motor coordination task did not deteriorate with sleep loss.		
	16.4 There was no deterioration of loading and unloading a rifle. However, time to disassemble/assemble a rifle deteriorated 23% after 2 days for the group with no sleep compared to the 1.5 and 3 hour sleep groups.	Learning was occurring during rifle assembly and the group with no sleep was not able to learn the task as well as the other groups.	1	1
	16.5 Encoding/decoding, logical reasoning and other cognitive tests degraded for all three groups at a rate of about 23% per day.	Cognitive performance degrades continuously and rapidly even with some sleep.	1	1
	16.6 EEG patterns indicated that many of the subjects had some unscheduled light sleep.	Some rest during lulls in battle may be possible during CONOPS.	2	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 017

SECURITY CLASSIFICATION. Unclassified

TITLE: Artillery teams in simulated combat: Performance and other measures. In biological rhythms, sleep and shift work. L. Johnson, D. Tepas, W. Colquhoun, and M. Colligan (Eds.), Jamaica, NY. Spectrum Publications, Inc.

AUTHOR(S): L.E. Banderet, J.W. Stokes, R. Francesconi, D.M. Kowal, and P. Naitoh

ORGANIZATION (AGENCY):

LOCATION:

DATE: 1981

SUBJECT: Two tests were conducted to evaluate FDC performance under sustained operations in simulated wartime conditions. In the first test, two 5 man FDC teams were to perform 6 hour scenarios for up to 86 hours with essentially no rest. In the second test, two 5 man teams were to perform 6 hour scenarios for 38 hours, then rest for 34 hours and perform again for 38 hours.

NATURE OF RESEARCH: CLE ___ CFE _X_ FOM ___
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION: OP _X_ MA ___ SU ___

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TYPE OF DATA: QT _X_ QL ___ SJ ___

AFV RELEVANCE: NO ___ SI ___ MO ___ HI _X_

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 017	17.1 In the 86 hour test, one team lasted 45 hours and the second team lasted 48 hours before voluntarily withdrawing from the test. In the double 38 hour test, both teams had no trouble completing their trials. Although subjects in the 38 hour tests were given a rest period, subjects on one of the teams were able to sleep very little.	Although the FDC teams did not last longer than 48 hours, the authors of the article thought that the termination was premature and may not occur in battle situations. Research should be performed in the area of determining methods to produce efficient sleep patterns in soldiers.	1	1
	17.2 Accuracy of firing data for all conditions was well maintained for unplanned missions. However, the teams in the 86 hour test showed progressive increases in 7-14 mil errors for preplanned target events. One of the 86 hour teams showed an increase in serious errors (30-1798 mils) from 24 to 48 hours.	Errors were caused for a variety of reasons such as omissions, incorrect copying, incorrect setting or reading of scales, digit reversals. Performance aids and automation of some of these functions may reduce the number and seriousness of these mistakes.	1	1
	17.3 Although the accuracy of unplanned missions was maintained, the latency with which the missions were accomplished increased for 3 of the 4 teams by 35% over initial values. The latency for on-call missions increased after 30 hours and 42 hours for the 86 hour test teams.	In sustained operations, time to complete both unplanned and preplanned missions will increase. Automation of some of these functions may reduce this decrement.	1	1
	17.4 An efficiency index of preplanned target processing was developed in which 0% meant no requests were processed and 100% indicated that instantaneous processing occurred. For the two 86 hour teams, efficiency dropped from an initial value of 77% to 33% and 42% after 42 hours and then one of the teams dropped to 18% for their last 3 hours.	Processing efficiency will drop drastically in sustained operations. The more prepared, trained, and organized a team is, the less affected they will be by reduced sleep.	1	1

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 017	17.5 Individual team member performance showed deficits of communications (requests for 'say again' increased from 1 in the first 12 hours to 28 after 24 hours), increased micro sleep (unresponsiveness to call signs increased from 1 in the first 12 hours to 8 after 24 hours), and inaccurate target plots increased for the HCO from 8% in the first 12 hours to 26% after 24 hours.	Many types of individual performance measures will suffer due to sleep loss. Task sharing or paralleling of critical tasks may be a useful means of reducing these deficits.	1	1

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 016	combat efficiency. The period of maximum efficiency began at about 10 days and lasted to about 30 days in combat. The period of combat exhaustion began at 30 days and showed a slow decline in combat efficiency to a vegetative phase at about 60 days.			

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 018	18.1 Estimates of the ratio of stress casualties to wounded in action (WIA) for WWII ranged from between .126 to .751 stress casualties to every 1 WIA. Between 1944 and 1945, the correlation between stress and WIA for many combat divisions was between +.70 and +.90.	Stress is directly related to battle intensity. As WIA increases, expect to see a corresponding increase in stress casualties. The search for methods for effectively coping with stress should continue.	2	2
	18.2 Hits on other friendly tanks on the Golan Heights in 1973 had little effect on one's own tank crew performance. However, hits on one's own tank or the loss of a fellow crew member caused tank crews to abandon useable tanks.	Instruments which indicate amount of damage sustained on a tank as well as the integrity of major systems on the tank may reduce the amount of stress associated with being hit.	1	1
	18.3 Expert psychiatrists feel that every soldier has a breaking point and that if kept in battle long enough, almost every soldier will become a stress casualty. In WWII in the MTO, the rate of stress casualties rose from 3.6 per thousand soldiers per day for the soldier's first 10 days in combat to 10.4 for between 51 and 80 combat days.	As the amount of time soldiers have been in combat increases, the number of stress casualties will also increase. Methods to reduce stress should be employed to allow effective CONOPS. These methods should include rest breaks, self relaxation and others suggested in FM 26-2.	2	2
	18.4 Swank and Marchand (1946) developed a model of the 'average' soldier's performance for soldiers in combat following the Normandy invasion. This model consisted of three primary phases. The initial adjustment phase lasted to about 10 days in combat and was characterized by an increase in	Expect maximum combat effectiveness to occur after 5 to 10 days in combat (but not in CONOPS). The effective use of training may reduce the initial adjustment phase.	3	3

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 018

SECURITY CLASSIFICATION: Unclassified

TITLE. Review of literature on the effects of selected human performance variables on combat performance - draft version.

AUTHOR(S): R. Michael and R Solick

ORGANIZATION (AGENCY). U.S. Army Research Institute Field Unit

LOCATION: Ft. Leavenworth, KS.

DATE: 1982

SUBJECT: The purpose of this paper was to develop more valid representations of human performance in combat models by reviewing the literature on the impact on human performance of radiation, stress, and fatigue. Special emphasis was given to quantitative data which could be used in combat model data bases. Generally, the interaction of those variables with other variables and the large individual differences found made it difficult to develop quantitative formulas which could be used in data bases.

NATURE OF RESEARCH: CLE ___ CFE ___ FOM ___
SIM ___ MOD ___ EJ _X_

MILITARY FUNCTION: OP _X_ MA ___ SU ___

MAJOR RISK AREA: EN ___ IP ___ HA ___ CO _X_ OH ___

TYPE OF DATA: QT _X_ QL ___ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO _X_ HI ___

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 019

SECURITY CLASSIFICATION: Unclassified

TITLE: Sleep deprivation and naps. Behavior Research Methods, Instruments, & Computers, 17, 46-54.

AUTHOR(S): Diana Haslam

ORGANIZATION (AGENCY):

LOCATION:

DATE: 1985

SUBJECT: Two field experiments were carried out to determine the effects of naps taken after sleep deprivation on cognitive performance. In the first experiment, 10 infantrymen were tested on physical and cognitive military tasks each day while being sleep deprived for 90 hours. At the end of the 90 hours, the men were given a two hour nap and then tested again. In the second test, cognitive performance of 6 infantrymen initially sleep deprived for 23 hours and then given one four hour nap each day for 5 days was compared to cognitive performance of six other infantrymen who were given 4 one hour naps each day over the 5 days of the test.

NATURE OF RESEARCH: CLE ___ CFE _X_ FOM ___
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TYPE OF DATA: QT _X_ QL _X_ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO ___ HI _X_

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 019	19.1 On a test involving encoding and decoding of grid references and letter codes, performance dropped about 35% for encoding (from 11 correct to 7 correct) and 50% for decoding (from 7 correct to 3 correct) over the 90 hours without sleep. However, performance both before and after the two hour nap was near baseline levels.	Decoding and encoding performance can be expected to drop from between 35% to 50% after 90 hours without sleep. However, this performance decrement may be temporarily reduced with the use of highly motivating factors such as the promise of sleep, R and R, etc.	1	1
	19.2 A Slidex decoding task (decoding of bigrams) degraded around 33% (from 42 correct to 28 correct) after 90 hours without sleep, but again recovered to baseline right before and after a 2 hour nap.	If sufficient incentive is given, temporary recovery in performance may be obtained. Further research must be carried out to determine 1) what incentives are sufficient and 2) how long the recovery period would last.	2	2
	19.3 There were no differences on any of the cognitive tests over the five days of the experiment between the group which was given one 4 hour nap and the group given four 1 hour naps. Also, there were no meaningful significant differences for the two groups over time indicating that performance was similar to baseline levels with the sleep regime instituted.	Four hours of sleep in each 24 hours appears to be sufficient to retain cognitive performance over 5 days. This sleep may be acquired as one 4 hour block or as 4 one hour naps. Depending upon scheduling restrictions, either method may be used with similar results.	1	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 020

SECURITY CLASSIFICATION: Unclassified

TITLE: Emplacing, firing and march ordering an M109A1 Howitzer: Tasks and task times.

AUTHOR(S): J. Coke, L. Crumley, and R Schwalm

ORGANIZATION (AGENCY): U.S. Army Research Institute (Research Report 1312)

LOCATION: Alexandria, VA.

DATE: June, 1981

SUBJECT: A computer based simulation model was developed to assess howitzer crew performance under continuous operations. The purpose of the present study was to determine relevant tasks and task times which could be used as input in the model. To this end, two howitzer crews performed a one day scenario which included 4 sequences of emplacement of the howitzer, firing three rounds, and then march ordering the howitzer. The results should be taken with some caution as only two crews were used and 12 fire missions made.

NATURE OF RESEARCH: CLE ___ CFE X FOM ___ SIM ___ MOD ___ EJ ___

MILITARY FUNCTION: OP X MA ___ SU ___

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TYPE OF DATA: QT X QL ___ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO X HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 020	20.1 A task list of approximately 200 tasks which were performed by a ten man howitzer crew was developed from FM 6-88, TM 9-2350-217-10N and WCXXMG, HO manuals.	The task list was developed to identify observable tasks which could be timed. The list may be useful for simulation or modeling.	2	3
	20.2 Minimum, average, and maximum times were obtained for each of of the tasks by videotaping two howitzer teams perform a series of maneuvers. The list of task completion times for the 200 tasks is too detailed for inclusion here. Some examples, however, are presented below: For fire mission: Time in Seconds Task / Min. / Average / Max Sets deflection 2.5 5.5 10.5 Traverses tube 4.0 9.0 13.0 Sets quadrant 2.0 4.5 10.5 Elev. tube to fire pos. call set 3.0 8.0 19.5	The findings from this study may be used as possible inputs for baseline rates of howitzer crews in simulation of degraded continuous performance. The authors caution that the times are based on a very small number of trials and crews and it is unsure how representative they are.	2	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 021

SECURITY CLASSIFICATION: Unclassified

TITLE: Soldier performance during continuous field artillery operations.

AUTHOR(S): J. Knapik, J. Patton, A. Ginsberg, D. Redmond, M. Rose, W. Tharion, J. Vogel, and F. Drews

ORGANIZATION (AGENCY): U.S. Army War College, Physical Fitness Research Institute (T1-87).

LOCATION: Carlisle, PA.

DATE: May, 1987

SUBJECT: One hundred and four field artillery soldiers in 3 howitzer batteries performed an 8 day CONOPS scenario which included 5-7 occupations and displacements each day as well as 60-120 fire missions each day. Prior to the study, the Alpha battery underwent a 10 week physical fitness program, the Bravo battery underwent 10 weeks of stress reduction drills, and the Charlie battery had no special training.

NATURE OF RESEARCH:	CLE ___	CFE _X_	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP _X_	MA ___	SU ___		
MAJOR RISK AREA:	EM ___	IP ___	MA ___	CO _X_	OH ___
TYPE OF DATA:	QT _X_	QL _X_	SJ ___		
AFV RELEVANCE:	NO ___	SI ___	MO _X_	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 021	21.1 There were no differences among the batteries both before and after the test for physical fitness, 2 mile run times, or muscle strength. This was thought due to a 50% compliance with the exercise program and 30% compliance with the stress program.			
	21.2 Command groups of batteries A, B, and C received 5.3, 4.6, and 5.3 hours of sleep a day.	The scenario used in this study enabled soldiers to get an adequate amount of sleep through careful scheduling.	2	2
	21.3 Significant increases in reported tension and fatigue occurred over the course of the test.			
	21.4 All batteries were able to maintain performance levels during the exercises.	The combination of sleep, physical fitness levels of the soldiers, adequate nutrition, and workload levels of the scenarios used enabled soldiers to perform adequately for 8 days.	1	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 022

SECURITY CLASSIFICATION: Unclassified

TITLE: Degradation of performance due to sleep deprivation: A field test. In M. Alluisi, S. Degroot, and E. Alluisi (Eds.), Proceedings of the Human Factors Society 28th Annual Meeting. Santa Monica, CA: Human Factors Society.

AUTHOR(S): C. Ball, T. Funk, D. Noonan, J. Velasquez and S. Konz

ORGANIZATION (AGENCY):

LOCATION: Santa Monica, CA.

DATE: 1984

SUBJECT: Thirteen soldiers were split into two groups and performed various military exercises in a 75 hour continuous operation. One group received 6 hours of sleep between hours 31 and 37 and between hours 67 and 73. The other group received 3 hours of sleep between hours 32 and 35 and between hours 65 and 68. There were a number of problems with this study (small sample size, use of tasks which were not well learned, etc). However, it still provides some useful data.

NATURE OF RESEARCH:	CLE ___	CFE X	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA ___	CO X	OH ___
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AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 022	22.1 Performance on map reading and decoding improved 20% over the course of the experiment.	These findings were thought due to learning effects. It should be noted that typically learning slows down when no sleep is given, so the sleeping schedules used in this experiment appear to be adequate to allow for learning to occur.	2	2
	22.2 There were no differences over time between the two groups on setting up a radio or performing a pegboard task. However, there was slight improvement in assembling an M16 rifle for the two groups over time.	These tasks were of short duration, highly overlearned, and relatively simple to perform. Tasks of this nature, performed by soldiers with between 3 to 6 hours of sleep in every 36 hours, do not appear to degrade over time.	2	2
	22.3 Subjective estimates of fatigue indicated that subjects with 3 hours of sleep in every 36 hours were more tired and felt worse than soldiers with 6 hours of sleep in every 36 hours.	Tasks which are of longer duration (greater than the 10 minute tasks used in this study), and are more complicated or require more cognitive processing may show decrements following the subjective pattern.		
	22.4 Both map reading and decoding demonstrated a drop in performance of 10% after sleep.	Performance on cognitive tasks tends to be slightly lower immediately after wakening from sleep. A fifteen minute recovery period in which the soldier performs light work may be useful to ease him into his work. Don't expect 100% performance from a soldier who just awoke.	2	2

AFV DATA COLLECTION SHEET

__ MENT IDENTIFICATION NUMBER: CO 023

SECURITY CLASSIFICATION: Unclassified

TITLE: Work-rest schedules under prolonged vibration with implications to military operations

AUTHOR(S) R.A Dudek, M M. Ayoub, M.A. El-Nawawi, and I.M. Khalil

ORGANIZATION (AGENCY): U S Army Human Engineering Laboratory. (Technical Memorandum 12 72)

LOCATION Aberdeen, MD.

DATE: April, 1972

SUBJECT. An experiment was conducted on a Single Station Crew and also on a Multi-Station Crew to assess the effects of work-rest schedules upon individual performance on a vertical compensatory tracking task performed under normal and vibratory environments.

NATURE OF RESEARCH:	CLE X	CFF ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA.	EN ___	IP ___	MA ___	CO X	OH ___
TYPE OF DATA	QT X	QL ___	SJ ___		
AFV RELEVANCE	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 023	Single Station Crew 23.1 A vibratory environment causes significant decrement in vertical tracking ability. Absolute tracking error was found to increase by as much as 43%. 23.2 In the 15/15 min work rest schedule, it was found that complete recovery from the effects of the vibration did not occur during the 15 min. rest period. 23.3 The 30/30 min work/rest schedule showed less decrement in performance and appeared to be the best work/rest schedule when compared with a broader range of work/rest schedules. Multi-Station Crew 23.4 Tracking error scores increased with a decrease in crew size. 23.5 The best performance was for crewmembers (8-man crew operating at 4 station work system) scheduled to work a 1/1hr work/rest schedule. 23.6 6 and 5-man crews scheduled to work the 2/1 and 4/1 work ratios respectively had higher tracking error scores.	The effects of vibration, crew size and work/rest schedules on tracking performance have direct impact upon AFV. In fact referring to vibration, it has been said that "... bounce and its secondary effects, notably resonances at low sonic frequencies, are a major factor in crew stress and fatigue. "... designers accept the need to protect electronic packs and optical instruments against this vibration by putting them on resilient mountings. They need to do the same for the crew" (Human Factors in Mechanized Warfare, Simpkin, 1983). Beyond the stress and fatigue mentioned is the tracking error rate pointed out in the studies mentioned. All these factors are obviously detrimental to the success of the mission. As shown in these studies, work/rest schedules are an important consideration in lessening the detrimental effects of vibration on performance; other improvements (e.g., seats, suspension) might further decrease these problems.	1	1

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 023	23.7 Tracking error scores increased up to 21% under vertical vibration. 23.8 In general the 30 min work cycle yielded lower tracking error scores than those obtained under the 60 min work cycle schedules.			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 024

SECURITY CLASSIFICATION: Unclassified

TITLE: Some observations from a literature review to anticipate biological problems that might arise in sustained and continuous operations.

AUTHOR(S): J.F. O'Hanlon

ORGANIZATION (AGENCY): U.S. Army Human Engineering Laboratory. (Technical Memorandum 12-72)

LOCATION: Aberdeen, MD.

DATE: 1971

SUBJECT: The implications of the research done on the effects of sleep deprivation and those of work under continuous operations are reported.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM ___		
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MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA ___	CO X	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 024	Sleep deprivation studies			
	24.1 Although many potentially dangerous physiological malfunctions result from various levels of sleep deprivation (e.g., Iron reclamation impairment, impairment of adrenal functions, pathologic electrocardiogram functions), the very first system to show definite impairment is the Central Nervous System. Fortunately, it is also the first to recover once the sleep deprivation ceases.	AFV the soldier fighting under continuous operations will most likely be subject to the stresses mentioned above, at possibly, a more intense level. Because of the small size of the AFV crew, ways must be found to regulate work/rest cycles adequately in order to decrease the effects of sleep deprivation. Given the highly technological nature of modern weaponry, computerized aids might be provided to help the soldier in the accomplishment of the cognitive tasks which will most likely be affected under continuous operations.	1	1
	Continuous operations studies			
	24.2 It is generally accepted by physiologist that "... the maximum allowable 24-hour energy expenditure for workers engaged in heavy labor on a daily 8-9 hour basis should not exceed 4800 kcal. Energy expenditure in excess of that is said to be associated with feelings of chronic fatigue and increased susceptibility to physiologic dysfunction of many kinds. Soldiers in continuous operations will routinely exceed that value. This will be further exacerbated by the added effects of other stressors on the soldier.	Another problem is that of water loss which might be exacerbated under conditions involving MOPP gear and/or high ambient temperatures; furthermore it might not be possible for the soldier to replace this water loss as often as he might desire.		
	24.3 Laboratory experiments have shown that for the average healthy male with a normal diet with an oxygen consumption of 3.5L, the rate of energy expenditure			

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 024	associated with physical work at about 50% and 25% relative maximum is approximately 9 and 5 Kcal/min, respectively. Under workloads greater than 70% of maximum, the limiting factor seems to be the depletion of muscle glycogen as well as exhaustion of liver glycogen leading to deterioration of central nervous system functioning.			
	24.4 Between 33% to 50% of maximum, sustained work can be hindered by progressive dehydration. Once dehydration occurs, the water loss can only be replaced at best over the course of hours, or of days.	Necessary precautions must be taken to decrease water loss (e.g. increase cooling either in AFV cabin or in MOPP gear design. Adopt work/rest schedule which will economize energy output.		
	24.5 Prolonged submaximal work has resulted in water losses of up to 8% of initial body weight. Water losses of 1%-2% only can cause circulatory strain and if unchecked lead to circulatory insufficiency and/or heat exhaustion.			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 025

SECURITY CLASSIFICATION: Unclassified

TITLE: Customer test of the surrogate research vehicle Phase 1B.

AUTHOR(S): J.F. Dedmon and R. Mielec

ORGANIZATION (AGENCY): U S. Army Armor and Engineer Board - (TRADOC Report TRMS-3-000314.)

LOCATION: Ft. Knox, KY.

DATE: 1984

SUBJECT: Data relevant to the Tank Test Bed (TTB) were obtained using the SRV for 3 72 hour continuous trials which included an average of 4 hours of sleep a night and the wearing of NBC gear for between 3 and 6 hours during the test. There were a number of limitations of the test which included 2 days of training rather than the 4 weeks requested, small sample sizes, and high familiarity with the scenarios

NATURE OF RESEARCH:	CLE ___	CFE X	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA ___	CO X	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 025	25.1 The Staget sights used in the SRV were connected to B & W television monitors or to standard M27 vision blocks. Target detection, vehicle movement and command and control using these sights were very poor due to 1) limited field of view; 2) poor visibility close to the vehicle: 3) the television monitors offered no depth perception; 4) vegetation, mud and smoke limited vision; 5) disorientation caused by difficulty in matching information from the vision blocks and TV monitors attributed to not knowing the direction of the sights to the hull.	The Staget system used on the SRV is not suitable for use on the AFV. A system which allows a 360 degree field of view, monitoring of areas near the vehicle, offers some means of determining depth (stereo vision, color coding, giving distance on a display), and allows the user to orient himself would be useful for the AFV.	1	1
	25.2 Percentages for the amount of time different crew members use different vision devices are presented in the report.	Percentages can be used to determine the type and positioning of sights for different crew members in the AFV.	2	2
	25.3 For the 72 hour CONOPS, with the exception of one test time, encoding and decoding performance were not a function of the amount of time into CONOPS. Also, a tracking board test, target detection tests, and a test of driving ability did not show any degradation over time.	A work/rest schedule which includes about 4 hours of sleep a night is sufficient to eliminate the detrimental effects of CONOPS for encoding and decoding, tracking, target detection and driving ability.	1	1
	25.4 It took 2-3 minutes longer to put MOPP gear on while in the SRV (9-15 minutes) than outside the SRV.	There is not enough room in the SRV to quickly put on MOPP gear. Either give more space in the AFV to allow getting into MOPP gear, develop clothing which can be more quickly put on, or ensure that the soldier will be safe until he can don MOPP IV.	1	2

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 025	25.5 Some useful results from a questionnaire include: 1) seat design made sleeping difficult; 2) Development of a better method for elimination of human waste was requested; 3) Prolonged sitting in the seat resulted in cramping and numbness in the legs, back, and tailbone; 4) TV monitoring resulted in eye fatigue; 5) Confined cabin made exercise difficult; 6) Insufficient space to treat wounded; 7) NBC mask made target detection difficult; 8) External communications should be added to the outside of the SRV; 9) Putting on and taking off MOPP gear was difficult in SRV (times ranged from 9-15 minutes); 10) Mud and dirt on vision blocks and TV cameras limited visibility; 11) Disorientation occurred while in MOPP gear and while using TV monitors.	Seats used in the AFV must be able to allow soldier to sit for 72 hours with little cramping or numbness. It would also be useful to develop seats which could be used for resting. Development of an efficient waste system is a must. The cabin in the AFV must be large enough to allow for minimal exercise and care of wounded, methods for clearing mud and debris from vision blocks and cameras should be investigated. The use of stereo cameras and careful placement of cameras are needed to reduce disorientation.	1	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO C26

SECURITY CLASSIFICATION: Unclassified

TITLE: Human factors in sustaining high rates of artillery fire.

AUTHOR(S): Frederick J. Manning

ORGANIZATION (AGENCY): Walter Peed Army Institute of Research, (WRAIR - NP-84-7.)

LOCATION. Washington, D.C.

DATE. 1985

SUBJECT: Observations and interviews were conducted with soldiers from a U.S. Army field artillery battalion stationed in West Germany. During the observations, field exercises, which included an 86 hour continuous operations exercise, were conducted. Also included in the report are findings from other previous field studies as well as recommendations for reducing the detrimental effects of CONOPS.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM X		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA ___	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA ___	CO X	OH ___
TYPE OF DATA:	QT ___	QL X	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 026	26.1 During REFORGER 78, a test of ability to deploy troops on short notice, senior officers and NCO's slept very little. Although tasks were delegated, responsibility was not.	Command and control tends to degrade faster than other types of tasks. Leaders must understand the importance of sleeping. Although it may be more 'manly' to stay awake, it will be to the detriment of the whole by way of poor decisions.	2	1
	26.2 44 Soldiers from the Royal Norwegian Military Academy participated in a 5 day ranger training course. The soldiers were sleep deprived for the first 3 days and several types of performance were tested. A coding test and a command memory test degraded to 65% of baseline levels after 3 days. Shooting performance, on the other hand, dropped only 10% from baseline levels after 3 days.	Again, command and control type tasks will degrade significantly, on the order of around 20% to 25% for each 24 hours. However, tasks of a more physical nature do not appear to degrade to a large extent over the same time period.	1	1
	26.3 Soldiers participating in an 86 hour field artillery field test quit after 48 hours. Forced paced activities produced well trained appropriate actions. The overall mission in terms of accurate and timely fires was carried out with little degradation, but self paced activities such as many safety measures, and intermediate steps were performed slowly or not at all.	The use of checklists, reminders, or other means of force pacing activities which tend to be self paced may reduce the number of safety, health problems and possible performance decrements associated with CONOPS. It may be useful, for example, to have a computer automatically switch to force pacing certain activities after 24 hours of CONOPS.	1	1
	26.4 The lowest morale, poorest performance, and quitting occurred between 0200h and 0600h.	0200 to 0600h is the trough of many circadian rhythms. Leaders should be aware that this will tend to be the most difficult time for soldiers. Performance aids may be required more during these times than at other times.	2	2

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CU 026	26.5 When NBC masks were worn, the driver and gun section chief were not able to communicate with others due to the nature of their equipment. This resulted in a massive attempt to manually shuttle information back and forth. Also, there was a high degree of skepticism among the soldiers as to the effectiveness of the NBC equipment.	NBC masks should allow all soldiers the ability to communicate with all other soldiers. Soldiers should be better educated in the effectiveness of the NBC suits.	2	2
	26.6 It was thought that there were three basic methods to extend unit performance: 1) Use of stimulants which maintain psychomotor and intellectual skills, 2) Allowing sub units to work to exhaustion and then replacing them, 3) rotating sub units to allow for work/rest schedules. Conversations with crew leaders indicated that commanders were unset with crews which instituted work/rest schedules because they were not snowing 'enthusiasm' and not 'going all out'.	Cross training will be important for any extended operations, and it is important for commanders to be aware that the use of work/rest scheuules is an important way to provide lasting effective performance.	2	1
	26.7 The authors give some generalizations as to what happens in organizations under high workload: 1) greater deviance from SOP and doctrine; 2) increased prioritization; 3) cross checking will decrease; 4) communications and record keeping will decrease; 5) communications with 'outside' groups will increase, 6) decision-making will tend to be transferred to group members with most experience; 7) interpersonal conflict will decrease; 8) attempts to	When AFV soldiers are under high stress or CONOPS, the use of check lists, forced pacing tasks, and other methods to reduce the possibility of not performing an important task should be considered. Reminder devices, automated check lists, etc, may be used to reduce the mundane tasks so leaders can concentrate on the more important tasks. Leaders will also tend to play an increasingly important role in raising morale and supporting tired troops.	1	1

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 026	'leave' physically and psychologically will increase.	The authors make 18 recommendations in regards to extended operations. Some of the most useful are presented here: 1) The importance of sleep and developing good work/rest schedules should be emphasized to soldiers of all levels; 2) Field exercises should allow for the use of work/-rest schedules; 3) Soldiers should be made aware of the circadian rhythm low points and with signs of stress and fatigue in soldiers; 4) More effective NBC communications equipment must be developed; 5) Increased emphasis on training exercises to allow soldiers to be familiar with NBC equipment.	1	1

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: CO 027

SECURITY CLASSIFICATION: Unclassified

TITLE. The effect of tank crew turbulence on tank gunnery performance

AUTHOR(S): N.K Eaton and J F. Neff

ORGANIZATION (AGENCY): U.S Army Research Institute (Technical Paper 350).

LOCATION: Alexandria, VA.

DATE: September, 1978

SUBJECT: In Phase I crew stability was assessed (personnel turbulence, and position turbulence. In Phase II the effects of the turbulence in personnel and positions on Table VIII were measured.

NATURE OF RESEARCH: CLS ___ CFE _X_ FOM ___
SYN ___ MOD ___ EJ ___

MILITARY FUNCTION: OP _X_ MA ___ SU ___

MAJOR RISK AREA: LN ___ IP ___ MA ___ CO _X_ OH ___

TYPE OF DATA: QT _X_ QL ___ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO ___ HI _X_

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
CO 027	27.1 Position familiarity of tank commanders and gunners plays a small, but reliable part in reducing opening time on Table VIII, and increasing the number of targets hit. 27.2 Whole crew familiarity did not have a significant effect on gunnery performance. 27.3 Crews in unfamiliar crew positions performed much more poorly than those in comparable crews who were familiar with their duties.	The results presented above are self-evident; yet their impact is not to be discounted. Turbulence in personnel and position is to be expected, especially to compensate for casualties. Therefore, this research has great import for the training of armor crews. The results seem to indicate that if position turbulence has more detrimental impact than personnel turbulence, crosstraining of armor crews in various armor positions would provide a greater probability of accomplishing the mission should casualties force such turbulence.		

MAINTENANCE (MA)

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 001

SECURITY CLASSIFICATION Unclassified

TITLE Develop and evaluate new training and performance systems for maintenance jobs Final report

AUTHOR(S). W R Harper, H K Simpson, R G. Fuller, and D.H Harris

ORGANIZATION (AGENCY) U S Army Research Institute (Research Note 82-14)

LOCATION. Alexandria, VA

DATE: April, 1981

SUBJECT. This report describes the development and evaluation of a Maintenance Performance System (MPS) to improve the performance of maintenance at the unit level. The system included methods for diagnosing maintenance performance problems with focus on those that could be improved thorough unit training. The research delt with wheeled and tracked vehicle maintenance.

NATURE OF RESEARCH	CLE ___	CFE X	FOM X		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP ___	MA X	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA:	QT X	QL X	SJ X		
AFV RELEVANCE	NO ___	SI X	MO ___	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 001	1.1 This work demonstrated that efforts directed toward increasing the skills of maintenance personnel in the unit are effective in improving maintenance and are well worth the effort. The report describes a system to assist the unit with this process.	This finding suggests that unit OJT may be an element worth including in the AFV training program.	1	3

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 002

SECURITY CLASSIFICATION: Unclassified

TITLE: Weapon systems: Shortfalls in automatic fault diagnostics.

AUTHOR(S):

ORGANIZATION (AGENCY): United States General Accounting Office (GAO/-NSIAD-87-98).

LOCATION: Washington, D.C

DATE: April, 1987

SUBJECT: Using a case study approach, GAO analyzed the automatic diagnostics of the Patriot, Hawk, Pershing, MLRS, Apache, and M1 Tank.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM X		
	SIM ___	MOD ___	EJ X		
MILITARY FUNCTION:	OP ___	MA X	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA:	QT ___	QL X	SJ X		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 002	2.1 Although performance of diagnostics varied by weapon and test, in general, neither built-in nor external diagnostics performed as expected during operational tests.	The GAO concluded that problems can be minimized through: a. greater emphasis on diagnostics early in program acquisition. b. better specification of diagnostic requirements. c. more thorough and earlier oversight and testing of diagnostics in weapons development programs.	1	2
	2.2 From a literature search, GAO identified that design requirements should include: a. percent of faults to be detected. b. percent of faults to be isolated. c. percent of faults to be isolated to one, two, three or more parts. d. percent of false diagnoses. e. time to diagnose faults. f. personnel skill levels. 2.3 BITE Performance MLRS — Goal / Independent Test / Project Office Fault isolation to one LRU — 90% / 15% / No data Maximum false removals — 7% / 54% / 8%	This finding may be useful in formulating requirements for diagnostic equipment in the AFV program.	1	2

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
KA 002	<u>Pershing</u> <u>Test Director</u> — <u>Correct Diagnosis</u> Contractor — 98% " — 88% Independent — 59% <u>Patriot</u> — <u>Goal</u> — <u>Actual</u> Fault detection — 99% — 88% Fault isolation — 75% — 62% <u>M1 Tank</u> Actions to correct test set shortfalls and improve troubleshooting will cost over $72 million.			

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER. MA 003

SECURITY CLASSIFICATION: Unclassified

TITLE Human problem solving in fault diagnosis tasks.

AUTHOR(S) W B Rouse, and R M Hunt

ORGANIZATION (AGENCY). U S Army Research Institute (Research Note 86-33)

LOCATION. Alexandria, VA

DATE April, 1986

SUBJECT Results of experiments on problem solving in a maintenance context, with and without computer aids, are reported

NATURE OF RESEARCH:	CLE X	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION.	OP ___	MA X	SU ___		
MAJOR RISK AREA:	EH ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA	QT X	QL X	SJ ___		
AFV RELEVANCE	NO ___	SL ___	MO ___	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
IIA 003	3.1 Twenty candidate measures of human performance were analyzed with unequivocal results. Among the 20 measures, there are only 3 unique dimensions: time, errors, and inefficiency. 3.2 Subject attributes examined were: Ability-as measured by standard scholastic aptitude tests. Aptitude-mechanical reasoning test. Cognitive sytle-two dimensions were measured: Impulsivity-reflectivity (matching familiar figures test) and Field dependence-independence (embedded figures test).	A single measure such as time or cost does not adequately describe human performance.	3	3
	Cognitive style was a much better predictor of problem solving performance than ability and aptitude after minimum standards of ability and aptitude are met. Impulsives made the most errors and impulsivity was not compensated for with practice. Reflective field independents were the best problem solvers.	This finding is related to the issue of selection standards for maintenance personnel.	3	3
	3.3 Human problem solving tends to be highly context-specific but pattern recognition capabilities are exceptionally good, thus allowing a high degree of accuracy in ambiguous problem solving situations. Structured-oriented bookkeeping aids improved performance while [illegible]gy-oriented aids had a negative [illegible] on transfer of training.	Humans can be taught general problem solving skills which transfer to specific problem solving situations. Humans have trouble making maximum use of the information available. Computerized aids improve human performance.	3	3

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 004

SECURITY CLASSIFICATION Unclassified

TITLE Test operations procedure: Test, measurement, and diagnostic equipment (system peculiar)

AUTHOR(S)

ORGANIZATION (AGENCY): Unites States Army Test and Evaluation Command (TOP-6-2-235).

LOCATION: Aberdeen Proving Ground, MD.

DATE: May, 1985

SUBJECT: An Army test procedure for testing system specific diagnostic equipment

NATURE OF RESEARCH CLE ___ CFE ___ FOM ___
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION: OP ___ MA _X_ SU ___

MAJOR RISK AREA: EN ___ IP ___ MA _X_ CO ___ OH ___

TYPE OF DATA: QT ___ QL ___ SJ ___

AFV RELEVANCE NO ___ SL _X_ MO ___ HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 004	This document is an *Army Test and Evaluation Command Test Procedure.*	The document contains, in appendix C, a checklist which may be useful in preparing RFP requirements for AFV diagnostic equipment.	3	3

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 005

SECURITY CLASSIFICATION: Unclassified

TITLE: Integrated logistic support lessons learned: Force modernization report No. 5; M1 Abrams tank.

AUTHOR(S):

ORGANIZATION (AGENCY): Unites States Army Materiel Readiness Support Activity.

LOCATION: Lexington, KY

DATE: 1984

SUBJECT: This document reports the logistic support lessons learned in fielding the M1 tank.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM X		
	SIM ___	MOD ___	EJ X		
MILITARY FUNCTION:	OP ___	MA X	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA:	QT X	QL X	SJ X		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 005	5.1 The quantities of manuals and STE-M1 test sets were inadequate to the needs of the school teaching organizational maintenance. There is high attrition of these items due to repetitive daily use.	Adequate quantities of documentation and equipment should be obtained for training purposes.	1	2
	5.2 Sustainment training within units is a problem due to personnel turnover and competing demands on unit time and resources.	Consider the need for unit sustainment training in designing AFV training.	3	2
	5.3 Troubleshooting was the number one weakness of organizational maintenance personnel.	This finding is important in designing AFV maintenance training.	2	1
	5.4 The PMCS pages of manuals should be made more durable so as to withstand weather exposure and daily use in the units.			
	5.5 Excessive detail in some task descriptions and extensive cross referencing make organizational maintenance manuals overly voluminous (16 vols.) and hard to use.	This finding has implications for the requirements statements covering manuals in the RFP.	2	3
	5.6 The STE-M1 was successful 16 out of 31 uses (52%) and had a reliability of 81%. The test set was judged to be overly bulky, took too long to set up (45 min. to 1 hr.), manuals were inaccurate and mechanics had difficulty relating the fault in the tank to the fault symptoms in the manual.	Bulkiness of the test set and excessive set-up time are due to the absence of a one point connector which was deleted from the tank design. The result is multiple test cables which must be connected at various locations in the tank, some of which are extremely difficult to hook up to.		

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 005	5.7 Cables, circuit boards and the set communicator were the source of numerous malfunctions which resulted in low availability of the STE-M1.	Difficulties with the STE-M1 resulted in a negative attitude toward the test set on the part of mechanics and a reluctance to use it even when it was available. Problems with cables and the set communicator were due to equipment inadequately designed for the conditions of use.	1	1
	5.8 Direct Support Electrical System Test Set (DSESTS) worked well, was reliable and training was adequate.	The characteristics accounting for the good performance and high acceptability of this test set are, unfortunately, not described in this document.		
	5.9 Three M1 maintenance procedures are inherently hazardous. These are, removal and replacement of the main gun mount and rotor, removal and replacement of the traversing mechanism, and removal of the powerpack.	The hazards arise from the necessity of handling very heavy items in very limited space. The finding has implications for design for ease of maintenance.	1	2
	5.10 The biggest problems affecting engine performance have been "coking" of fuel nozzles and starter failures. The M1 Sample Data Collection (SDC) has also shown the following to date: Problem — # of cases Transmission oil temp warning — 19 Transmission filler tube cracked — 17 Loss of steering — 7 Transmission oil leaks — 6 Low transmission oil pressure — 6	This finding has implications for AFV design.	3	3

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 006

SECURITY CLASSIFICATION. Unclassified

TITLE Army maintenance: Continuing problems in performing maintenance at the user level.

AUTHOR(S).

ORGANIZATION (AGENCY): United States General Accounting Office

LOCATION: Washington, D.C

DATE: April, 1987

SUBJECT: GAO reviewed tracked and wheeled vehicle maintenance in 5 of the Army's 16 active divisions. They analyzed 285 inspection reports by Inspector Generals and Maintenance Evaluation Teams covering the period Oct. 83 to Dec. 85. The inspections included 5,539 wheeled and tracked vehicles from 602 company-size units. GAO compared inspection results with equipment mission-capable rates as reported by commands inspected. GAO also documented management problems, scheduled service, parts supply, training, record keeping, and reporting. They made site visits (4 in CONUS and 2 OCONUS), gathering interview and questionnaire data on maintenance problems and possible solutions. GAO also analyzed several units that inspectors had cited for successful maintenance operations. Tracked vehicles numbered 1,599 and included: M1, M60, M40/551, M578, M88, M113, M2/3, M548, M577, M901, M106, M109, M110, M163, M730

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM X		
	SIM ___	MOD ___	EJ X		
MILITARY FUNCTION.	OP ___	MA X	SU ___		
MAJOR RISK AREA.	EN ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA.	QT X	QL X	SJ X		
AFV RELEVANCE.	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 006	6.1 Reports said 82% to 93% of vehicles were mission-capable. Inspections placed 50% in in-operable status.	Lack of command emphasis over supervision, training, and resources management led to: a. failure to detect and correct equipment deficiencies. b. improper maintenance performance. c. insufficient use of diagnostic equipment.	2	1
	6.2 Inspector General and Maintenance Evaluation Team reports (n=285) showed: a. daily PMCS not completed or recorded (54% of reports) b. periodic servicing not scheduled or performed (35% of reports)			
	6.3 Army sample data collection results showed that 37% to 47% of howitzer and M578 recovery vehicle failures are caused by improper preventive and corrective maintenance, carelessness, and operator error. Hardware, or equipment design failures account for the rest.	More than 50% of howitzer and M578 recovery vehicle failures are due to hardware or design failures. However, the balance are attributed to human failure.	1	1
	6.4 Successful maintenance operations are characterized by: a. Emphasis by local command on vehicle maintenance. b. thorough first-line supervision of operator PMCS. c. sufficient operator and first-line supervisor PMCS training (formal and OJT). d. Sufficient parts, tools, publications, personnel, and time for maintenance activities.			

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 006	6.5 The army teaches M1 tank mechanics only 29% of the critical tasks, enough for apprenticeship. Balance of training is done in the units.	This finding highlights the importance of effective AFV maintenance training.	1	2
	6.6 Army study showed that diagnostic test sets were used to identify only 2 of 537 maintenance failures on 150 commercial utility cargo vehicles during a 6-month period.	Reasons given are: a. Test sets too time-consuming and cumbersome to use. b. Personnel do not know how to use them. This suggests that diagnostic equipment must be human engineered and integrated into training programs.	1	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER. MA 007

SECURITY CLASSIFICATION. Unclassified

TITLE: Reverse engineering of the M1 fault detection and isolation subsystem. Human factors, manpower, personnel, and training in the weapons system acquisition process (ARI Research Note 84-101).

AUTHOR(S): A. Marcus, and J Kaplan

ORGANIZATION (AGENCY): U.S. Army Research Institute (Research Note 84-101)

LOCATION: Alexandria, VA.

DATE: June, 1984

SUBJECT: Strengths and weaknesses of the M1 fault detection and isolation subsystem were examined through a retroactive analysis (Reverse Engineering)

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM X		
	SIM ___	MOD ___	EJ X		
MILITARY FUNCTION:	OP ___	MA X	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA:	QT X	QL X	SJ X		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 007	7.1 Inadequacies resulted more from management omissions than from technical issues: a. Early requirements documents neglected maintenance performance. b. Critical tasks not identified. c. No requirement to document time for task performance. d. Funding constraints prevented proper ILS effort. e. Inadequate testing for logistic supportability. f. Test sets not developed as part of tank hardware design led to problems.	Adherence to MANPRINT principles throughout AFV acquisition process should avoid repetition of these errors.	1	1
	7.2 M1 BITE not adequately tested and evaluated.	Do not rely only on M1 BITE information in making AFV decisions.	1	2
	7.3 STE/M1 seldom used (3%) to help troubleshoot. When used, it requires, on average, 6 hours per maintenance incident (requirement is 4 hours).	Test sets should be an integral part of system design and development, not an isolated after-thought.	1	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER   MA 008

SECURITY CLASSIFICATION. Unclassified

TITLE: A study of cold weather organizational maintenance problems (M29, M59, M76).

AUTHOR(S): D K. Andrew

ORGANIZATION (AGENCY)   U S Army Human Engineering Laboratory (Technical Memorandum 6-57)

LOCATION: Aberdeen Proving Ground, MD

DATE. August, 1957

SUBJECT: Difficulties of conducting maintenance on 3 specific vehicles under artic conditions were examined.

NATURE OF RESEARCH.	CLE ___	CFE ___	FOM X		
	SIM ___	MOD ___	EJ X		
MILITARY FUNCTION:	OP ___	MA X	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA:	QT ___	QL X	J X		
AFV RELEVANCE.	NO ___	SL X	MO ___	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 008	8.1 Based on interview data and field observations (1957) it was concluded that at minus 28°F, with no shelter or heat, vehicle maintenance can be performed approximately 15 minutes out of each hour. (This was maintenance on mechanical components).		2	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 009

SECURITY CLASSIFICATION: Unclassified

TITLE: Human factors evaluation checklist for tanks

AUTHOR(S): J.H. Clingan, and R.C. Akens

ORGANIZATION (AGENCY). U.S Army Human Engineering Laboratory (Technical Note 6-86)

LOCATION. Aberdeen Proving Ground, MD.

DATE: October, 1986

SUBJECT: This document contains a useful checklist.

NATURE OF RESEARCH.	CLE ___	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP X	MA X	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA:	QT X	QL X	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 009	This checklist for evaluating human factors in tanks contains no data but does contain highly useful guidelines for maintenance design features.	This document could be useful in stating maintenance features desired in design of AFV.	1	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 010

SECURITY CLASSIFICATION. Unclassified

TITLE: Missile component repair while wearing NBC protective clothing.

AUTHOR(S): J.D. Waugh, and P W. Kilduff

ORGANIZATION (AGENCY): U.S Army Human Engineering Laboratory (Technical Memorandum 1-84)

LOCATION: Aberdeen Proving Ground, MD.

DATE: January, 1984

SUBJECT: Measured the time to complete repair task as function of amount of protective clothing worn Nine subjects performed 2 tasks (easy, & difficult), three times under each of 4 conditions Dependant measure was time to complete repair tasks. Manuals were available Conditions were:

1. Duty uniform only.
2. Duty uniform and mask/hood.
3. Duty uniform and gloves.
4 Full MOPP gear.

NATURE OF RESEARCH:	CLE ___	CFE X	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OF ___	MA X	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE	NO ___	SL ___	MO ___	HI X	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 010	10.1 Task completion was not affected by the four conditions for "easy" task (Tow self-test). 10.2 MOPP 4 condition increased repair time for difficult task (Dragon night sight) by 45%. 10.3 Mask/hood and gloves conditions increased time by 18% on difficult task.	Reducing repair task complexity shortens repair time, especially under MOPP conditions.	1	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 011

SECURITY CLASSIFICATION: Unclassified

TITLE: A proposed limit for printed-circuit board insertion forces

AUTHOR(S): R.B Randell

ORGANIZATION (AGENCY): U S Army Human Engineering Laboratory (Technical Note 2-71)

LOCATION: Aberdeen Proving Ground, MD

DATE: March, 1971

SUBJECT: In a laboratory setting, 24 male subjects pushed against a handle attached to a chatillon push-pull gauge. Each subject pushed as hard as possible with his thumb for 3-5 seconds, then "lunged" to achieve maximum force. The handle was pushed both horizontally and vertically downward.

NATURE OF RESEARCH:	CLE X	CFF ___	FOM ___		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP ___	MA X	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA:	QT X	QL ___	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
HA 011	11.1 From the subject data, it was calculated that 99.5% of the military population could exert a force of 25 pounds or more in the horizontal direction.	The 25 pounds is a useful design figure for male soldiers. No data on female soldiers.	2	3

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 012

SECURITY CLASSIFICATION: Unclassified

TITLE: Problems in organizational level maintenance on the M60A1 and M48A5 tanks.

AUTHOR(S): T.R. Actkinson

ORGANIZATION (AGENCY): U.S. Army Research Institute (Research Problem Review 78-15)

LOCATION: Alexandria, VA.

DATE: August, 1978

SUBJECT: Interview and questionnaire data were gathered from 3 Army units and one National Guard unit concerning maintenance problem areas on M60A1 and M48A5 tanks.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ _X_		
MILITARY FUNCTION:	OP ___	MA _X_	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA _X_	CO ___	OH ___
TYPE OF DATA:	QT ___	QL _X_	SJ _X_		
AFV RELEVANCE:	NO ___	SL _X_	MO ___	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 012	12.1 Item mechanics believed most difficult to repair were the generator, brakes, final drives and the add-on stabilization.	Emphasize design for maintainability.	1	2
	12.2 Tools were inadequate and in short supply.	Tool sets are part of system fielding.	1	2
	1 .3 Crew PMCS was often not done or done improperly.	Design for ease of maintenance, prepare effective training programs and include supervision in considering TOE's.	1	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 013

SECURITY CLASSIFICATION: Unclassified

TITLE: Research findings to aid supervisors and trainees in improving maintenance performance.

AUTHOR(S): R.P. Kern and J.F. Hayes

ORGANIZATION (AGENCY): U.S. Army Research Institute (Research Product 83-14)

LOCATION: Alexandria, VA.

DATE: November, 1983

SUBJECT: 236 organizational level mechanics in five combat arms divisions were observed performing regularly assigned organizational level maintenance tasks in their normal shop environments. Activities were analyzed into "remove", "install/replace", "adjust", and "service" categories. This was mechanical maintenance on M60 tanks, M113 APC's, and 1/4 ton, 2 1/2 ton and 5 ton trucks. Performance by mechanics of 3 different levels of experience was analyzed for:

a. Use of information sources.
b. Types of information sought.
c. Occurrence of errors
d. Types of errors
e. Types of serious, uncorrected errors remaining upon completion of performance.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM X		
	SIM ___	MUO ___	EJ ___		
MILITARY FUNCTION:	OP ___	MA X	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA:	QT X	QL X	SJ ___		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
HA 013	13.1 For activities requiring special tools or technical specifications (ST/TS), 71% of the mechanics left one or more serious errors uncorrected.	Keep special tools to a minimum. They tend to be unavailable or not used.	1	2
	13.2 For activities not requiring ST/TS, 22% of mechanics left one or more serious errors uncorrected.	Design for simplicity of maintenance. Mechanic tends to use trial and error. i.e., observers reaction or effect from equipment.	1	3
	13.3 Overall, 66% of the mechanics failed to perform the required checkout after repair or performed it incorrectly.	Mechanic is sole judge of his own performance. This lack of supervision emphasizes importance of initial training.	1	3
	13.4 Experienced mechanics were more likely to perform checkout than inexperienced mechanics but they were no more likely to perform it correctly.	Lack of corrective feedback perpetuates errors. Failure of OJT.		
	13.5 Experienced mechanics do not differ from the inexperienced in level of skill and efficiency exhibited during performance and both are equally likely to leave serious errors uncorrected.	Emphasizes importance of formal training, supervised OJT and supervised quality control.	1	2
	13.6 TM's were used by 13% of the mechanics performing tasks requiring use of TM. They were primarily the less experienced.	Design for ease of maintenance. Build-in indicators for items requiring reference to TM's for proper adjustment.	1	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 014

SECURITY CLASSIFICATION: Unclassified

TITLE: Reverse engineering of the multiple launch rocket system: Human factors, manpower, personnel, and training in the weapons system acquisition process.

AUTHOR(S): J.M. Arabian, C.R. Hartel, J.D. Kaplan, A. Marcus, and D.M. Promisel

ORGANIZATION (AGENCY): U.S. Army Research Institute (Research Note 84-102)

LOCATION: Alexandria, VA.

DATE: June, 1984

SUBJECT. Review ("Reverse Engineering") of the weapons system acquisition process for the Multiple Launch Rocket System (MLRS) examined problems in human factors, manpower, personnel and training areas. The focus was on problem identification, origins of the problem and how it could have been avoided.

NATURE OF RESEARCH:	CLF ___	CFE ___	FDM X		
	SIM ___	MOD ___	EJ X		
MILITARY FUNCTION.	OP ___	MA X	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA:	QT X	QL X	SJ ___		
AFV RELEVANCE.	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
HA 014	14.1 BITE design goal was to correctly identify faulty LRU's 90% of the time with a false removal rate not to exceed 7%.			
	In OT III, there were 23 (15%) correct fault isolations out of 232 incidents; of 54 LRU's removed on the basis of BITE indications, 29 (54%) were serviceable.	Design of BITE and training in its use need intense management and technical attention in AFV acquisition process.	1	1
	14.2 DS maintenance training was based on use of actual equipment. This was an ineffective approach, resulting in a crash program for a maintenance trainer.	A thorough analysis of AFV maintenance training requirements and the means to fulfill them should be part of AFV acquisition process.	1	2
	14.3 The QQPRI did not take into account the complete functioning weapon system, i.e., the MLRS battery. As a result, a requirement arose for 246 additional manpower spaces for 26 MLRS batteries. Some of this was due to poor estimates of Direct Productive Annual Maintenance Manhours.	Maintenance manpower requirements must be carefully determined and fed into the QQPRI.	1	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 015

SECURITY CLASSIFICATION: Unclassified

TITLE: Human factors engineering design criteria for future systems. Report No. 1: Tank Design criteria evolving from the M1 Tank operational Test III.

AUTHOR(S): W.K. Earl

ORGANIZATION (AGENCY): U.S. Army Research Institute (Research Product 84-05)

LOCATION: Alexandria, VA.

DATE: March, 1984

SUBJECT: Human factors engineering issues distilled from OT III on M1 Tank are analyzed in this report.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM X		
	SIM ___	MOD ___	EJ X		
MILITARY FUNCTION:	OP ___	MA X	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA:	QT ___	QL X	SJ X		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 015	The findings with maintenance implications were:			
	15.1 Mud builds up under rear skirts and fenders causing a maintenance problem and stalling the tank.	Examine feasibility of built-in mud removing devices.	1	3
	15.2 Transmission needs a drain system to drain off excess oil from overfilling.	This is a design feature which will facilitate servicing the transmission.	1	3
	15.3 No provision for carrying spare track sections on the tank.		1	3
	15.4 Bracket holding the firing circuit cable obstructs maintenance of the main gun.	Design for ease of maintenance.	1	2
	15.5 The quart scale on the engine oil dipstick omits minus (-) symbols thus causing confusion.	Information must be displayed clearly and unambiguously.	1	2
	15.6 Many before-operation PMCS are assigned as after-operation PMCS.		1	2
	15.7 Several essential tools are not listed in the TOE.	Points to a possible coordination or review and evaluation problem.	1	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 016

SECURITY CLASSIFICATION: Unclassified

TITLE: Bradley Infantry fighting vehicle procedures guide: Driver.

AUTHOR(S): M.S. Salter

ORGANIZATION (AGENCY): U S Army Research Institute (Research Product 84-03)

LOCATION: Alexandria, VA

DATE. February, 1984

SUBJECT: Contains a PMCS checklist

NATURE OF RESEARCH:	CLE __	CFE __	FDN X		
	SIM __	MOD __	EJ X		
MILITARY FUNCTION:	OP __	MA X	SU __		
MAJOR RISK AREA:	EN __	IP __	MA X	CO __	OH __
TYPE OF DATA:	QT __	QL X	SJ X		
AFV RELEVANCE.	NO __	SL __	MO X	HI __	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 016	16.1 Contains a PMCS checklist for Bradley IFV driver.	May provide guidelines useful in preparing AFV PMCS materials.	1	3

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 017

SECURITY CLASSIFICATION: Unclassified

TITLE: Operational maintenance performance.

AUTHOR(S): J.D. Dressel and J.L. Shields

ORGANIZATION (AGENCY). U S Army Research Institute (Research Problem Review 79-8)

LOCATION: Alexandria, VA.

DATE: April, 1979

SUBJECT. This report presents the findings of a measurement of organizational-level maintenance performance in a brigade-sized unit during a 1-year period. Records were kept of items from M551 turrets submitted for direct support maintenance.

NATURE OF RESEARCH: CLE ___ CFE ___ FOH X
SIM ___ MOD ___ EJ ___

MILITARY FUNCTION. OP ___ MA X SU ___

MAJOR RISK AREA: EN ___ IP ___ MA X CO ___ OH ___

TYPE OF DATA: QT X QL ___ SJ ___

AFV RELEVANCE: NO ___ SL ___ MO X HI ___

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
HA 017	17.1 A total of 584 items were submitted for repair. Of these, 246 (42%) were false removals (serviceable items). 17.2 Total repair time was 1,146 hours, of which 367 hours (32%) was spent identifying serviceable items. 17.3 Total down time was 3,295 days, of which 989 days (30%) was due to false removals. 17.4 Average time to repair an item was 2.3 hours. Average time to identify a false removal was 1.5 hours.	Findings hold implications for ATE and training in the AFV program.	1	3

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 018

SECURITY CLASSIFICATION: Unclassified

TITLE: Field-expedient maintenance experiences of M60-series tank crewmen.

AUTHOR(S): D.G. Witmer

ORGANIZATION (AGENCY): U.S. Army Research Institute (Research Report 1345)

LOCATION: Alexandria, VA.

DATE: September, 1983

SUBJECT: 76 incidents of field-expedient maintenance on M60 tanks were collected from 33 NCOs using the critical incident technique.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM ___		
	SIM ___	MOD ___	EJ X		
MILITARY FUNCTION:	OP ___	MA X	SU ___		
MAJOR RISK AREA:	CM ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA:	QT ___	QL ___	SJ X		
AFV RELEVANCE:	NO ___	SL X	MO ___	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 018	18.1 Of the 76 repairs, 25% involved the suspension system. The remaining 75% were fairly evenly distributed over other subsystems, these were: air cleaning systems, cooling, steering, braking system, fire control system, sighting system, transmission, ignition, and fuel systems.	This finding highlights weak links in vehicle system design which may be avoided or improved in AFV.	2	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 019

SECURITY CLASSIFICATION: Unclassified

TITLE: Human factors engineering design criteria for future systems, Report No. 3. Design criteria evolving from the multiple launch rocket system (MLRS) operational test III.

AUTHOR(S): W.K., Earl and L.M. Crumley

ORGANIZATION (AGENCY): U.S. Army Research Institute (Research Product 85-05)

LOCATION: Alexandria, VA.

DATE: January, 1985

SUBJECT: This report analyzes human factors engineering problems experienced during Operational Test III on the MLRS.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM X		
	SIM ___	MOD ___	EJ X		
MILITARY FUNCTION:	OP ___	MA X	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA X	CO ___	OH ___
TYPE OF DATA:	QT ___	QL X	SJ X		
AFV RELEVANCE:	NO ___	SL ___	MO X	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 019	19.1 Screw down latches on the air filter panel are difficult to fasten and release. 19.2 Cables are difficult to connect and disconnect mostly due to small compartments and restricted access. 19.3 Hold down latches on the Launcher Loader Module handles, are difficult and dangerous to operate because they are under great pressure in the latched position. Unlatching requires counter force to prevent operator injury. 19.4 The hexagonal latching nuts on the battery box hold down brackets require too much time to remove for routine PMCS. 19.5 Drain plugs are too small to rapidly drain rear hull area. Also, plugs are not located at lowest point of area to be drained.	Findings reemphasize the need to adhere to existing standards on quick release fasteners, working access and safety restraints involving potentially dangerous components.	1	2

AFV DATA COLLECTION SHEET

DOCUMENT IDENTIFICATION NUMBER: MA 020

SECURITY CLASSIFICATION: Unclassified

TITLE: Maintenance performance system (organizational) operator and organizational maintenance practice.

AUTHOR(S): R.G. Fuller, S.M. Rugge, D.H. Harris, M Drillings and M. Berkowitz

ORGANIZATION (AGENCY): U.S. Army Research Institute (Research Note 84-9)

LOCATION: Alexandria, VA.

DATE: January, 1984

SUBJECT: This report describes operator and organizational maintenance practice in a sample of battalions within a mechanized infantry division. The report also describes variations of maintenance practice from maintenance doctrine.

NATURE OF RESEARCH:	CLE ___	CFE ___	FOM _X_		
	SIM ___	MOD ___	EJ ___		
MILITARY FUNCTION:	OP ___	MA _X_	SU ___		
MAJOR RISK AREA:	EN ___	IP ___	MA _X_	CO ___	OH ___
TYPE OF DATA:	QT ___	QL _X_	SJ _X_		
AFV RELEVANCE:	NO ___	SL ___	MO _X_	HI ___	

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 020	20.1 Before-operation checks are usually done during PMCS periods and before operating vehicles in the field. During-operation checks are usually made only after equipment breaks down. After-operation checks are usually not performed.	The findings generally emphasize the importance of designing for ease of maintenance and suggest a need for improved maintenance training.	1	3
	20.2. Typically, no maintenance training for operators or crews is done by the units, nor is any shown on the training schedule.		2	3
	20.3 PMCS periods are devoted to getting equipment off deadline, i.e., fixing faults that have already occurred rather than preventing new ones.		1	2
	20.4 Approximately 75% of operators had a-10 level TM for their equipment. Many TM's were not current or were not the correct version for the equipment on-hand.		3	3
	20.5 TM's and checklist are not routinely used by operators who depend, instead, on their memory. Likewise, mechanics generally rely on their experience or consult someone also in lieu of using a TM.		3	3
	20.5 Availability of current maintenance publications appears to be a problem at company level.		3	3

AFV FINDINGS/ISSUES WORKSHEET

RISK AREA	FINDING	MANPRINT/HUMAN PERFORMANCE ISSUE	RELEVANCE	CRITICALITY
MA 020	20.6 TOE provided one clerk to handle both PLL and TAMMS. Workload required the companies to assign a second person to clerk duties. Also assigned a mechanic to work in tool room because TOE does not authorize tool room clerk.	This finding highlights Manpower issue of concern because AFV concept is to field complete units.	2	3
	20.7 PMCS is covered only briefly in operator's AIT so the operators know little about it upon arrival at the unit. Unit conducts no formal training. Most of what the operator knows about PMCS is learned from informal OJT.	This finding highlights importance of including maintenance training in training analyses for AFV.	1	2